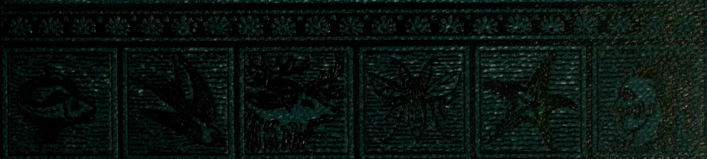


STANDARD NATURAL HISTORY



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NATURAL HISTORY OF ARTHROPODS.

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Eupagurus bernhardus, hermit crab.

THE STANDARD
NATURAL HISTORY.

EDITED BY
JOHN STERLING KINGSLEY.

VOL. II.
CRUSTACEA AND INSECTS.

Illustrated
*BY SIX HUNDRED AND SIXTY-SIX WOOD-CUTS AND TWENTY
FULL-PAGE PLATES.*

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NATURAL HISTORY OF ARTHROPODS.

BRANCH VII. — ARTHROPODA.

CUVIER, in his great divisions or branches of the animal kingdom, recognized a group Articulata characterized by having a bilaterally symmetrical body, composed of a series of rings or segments serially arranged. An excellent example of the arrangement of these rings can be seen in the common earth or angleworm. These rings make a hardened external skeleton, which at once forms a framework for the attachment of muscles, and also a protection for the internal organs. Typically, there is found in each segment a portion of each of the more important organs of the body. Just under the dorsal surface is found an elongated dorsal vessel, which represents the heart; the intestine lies in the median line of the body, which it usually traverses from end to end, while the nervous system, consisting of a series of enlargements, called ganglia, connected by nervous cords, extends along the floor of the body. This group of Articulata was still further divided into three classes: Worms, Crustacea, and Insects.

This classification was long prevalent, and even at the present time it is found in use in a few text-books, though when naturalists came to study more thoroughly the principles upon which animals should be grouped, and especially upon applying the revelations of embryology, it was seen that the class of Worms contained the most heterogeneous elements, and that while certain members of it were possibly closely related to Crustacea and Insects, the great majority had no such affinity, and that the features uniting them were of not so much importance as many others. Hence, as we have seen in the preceding volume, the group of Articulata has been dismembered and dropped from use, and even the class of worms is far from being a natural one.

According to the majority of the naturalists of the present day, the Crustacea and the Insects are together considered as forming a sub-kingdom, ARTHROPODA (*ἄρθρον*, a joint, and *πούς*, *ποδός*, a foot), but the tendency of scientific thought at the present time is toward the discarding of this group, and toward the belief that the Crustacea and the Insects are generically no more closely related to each other than they are to the worms, and that each should be raised to the dignity of branches. The reasons for such a course are many, but for convenience, in the present work, the prevailing classification will be retained.

The Arthropoda have the following features in common, some also being common to many worms: The body is (except in a few forms, the result of adaptation), bilaterally symmetrical, one side being a repetition of the other; and is made up of a varying number of rings (called segments, somites, or arthromeres) arranged one after another, and each ring theoretically bearing a pair of appendages, which in turn are jointed to

admit of a freedom of motion. In many cases, as in most insects, it is found that all traces of these appendages have disappeared from some of the body segments, though where we examine the larvæ or immature stages, we find that the generalization is fully justified, and that in the most generalised types each of these segments also bears a pair of limbs. This segmentation of the body and appendages is almost entirely confined to the external portions, the nervous system alone exhibiting a similar character, and, though constant throughout the group, it seems to be a secondary feature, and the result of a provision for movement rather than a fact of great morphological importance. This external envelope of the body is of cutaneous origin, and is rendered firm and hard by a peculiar organic substance known as chitine. This chitine, first made known by Odier, resembles the cellulose of plants in not being dissolved in caustic potash, but it differs essentially from it in containing nitrogen. In addition to this chitine there are frequently present in the exo-skeleton salts of lime, calcic-phosphate and carbonate, which render it much harder, and consequently more of a protection to the animal.

The rings of the body and the appendages which they bear, are variously modified according to the parts they have to protect and the functions they have to perform. Some of the appendages are adapted for walking, some for swimming, some for the seizure and mastication of food, while others play a part in the respiration, and still others give support to organs of sense. Of these appendages and their structure we shall speak more in detail in the succeeding pages.

In their internal structure the Arthropoda agree in many important particulars, but it is to be noted that in many respects these characters are common to other groups of Invertebrata, a fact which renders them of less weight in defining the Branch Arthropoda. The heart is usually an elongate tube on the dorsal surface of the body, is usually provided with valves, and serves for the propulsion of the blood, generally in a direction from behind forward. The arteries have proper walls, but the venous system consists merely of spaces or *lacunæ* between the various organs. The blood is usually colorless, but occasionally is yellow or red, or even purple, but the color belongs to the fluid itself, not to the contained globules.

The principal nervous system consists of a series of ganglia, or nervous centres, normally one to each segment, connected by a double longitudinal cord. This correspondence of ganglia and segments is the most evident instance of a segmentation of the internal organs. The first ganglion or "brain" lies in front of the mouth, and from it arise the nerves going to the eyes and antennæ. The two nervous cords connecting it with the rest of the nervous system pass one on either side of the œsophagus and enter the first of the series of infra-œsophageal ganglia. Thus we see that the alimentary canal passes through the nervous system, a feature which has its analogies, if not homologies, in other groups of the animal kingdom, and notably among most of the worms and molluscs. The posterior portion of the chain lies on the floor of the body-cavity, and, as has been said, normally consists of a series of ganglia, one to each segment, but frequently some of the ganglia are fused together, and where, theoretically, there should be several ganglia but one compound one is found. Each ganglion gives off nerves to the adjacent organs, and where we find two or more ganglia united, the nerves usually remain separate, thus clearly showing just what has taken place. A secondary nervous system is frequently well developed, analogous to the sympathetic system of the Vertebrata, and with a somewhat similar distribution.

The alimentary canal is usually nearly straight, traversing nearly the entire length of the body, and for the greater part of its course lying between the nervous and cir-

culatory centres. The mouth is on the lower anterior surface of the body, and is surrounded by the "mouth-parts" (the appendages of the adjacent segments, variously modified for the purposes of eating). These are sometimes adapted for crushing and biting, at others for piercing and sucking. Usually these mouth-parts are capable of motion, but they move in a horizontal plane, from side to side, and not vertically, as do the jaws of vertebrates. From the mouth the œsophagus passes upward and backward through the nervous system, as has been described, and terminates in the Crustacea at the stomach, in the insects at the crop or ingluvies. The rest of the course of the alimentary canal presents so many variations that it is best to resume the subject in connection with the different groups, and to close our account of it here with the statement that in many forms the canal is a simple tube with no well-defined divisions.

In the Arthropods two types of eyes are found, simple and compound, both sometimes occurring together in the same animal. These eyes have recently been made the subject of very exhaustive studies by Grenacher and others, but their accounts are too long for detailed insertion here. The simple eyes consist of a thickening of the outer integument, forming at once a refractive lens and an organ of defense. Beneath this lens the cells of the hypodermis become elongated. In the outer cells pigment is deposited, but the inner are transparent, and the lower ones, which are in connection with filaments of the optic nerve, form a retina. Various modifications of this structure are found, all, however, being reducible to this type. In most cases the anterior portion of the retinal cells become elongated into a "rod," while the anterior transparent cells frequently break up into a corresponding number of highly refractive bodies, known as crystalline cones. Each of these cones has its base placed against the corneal lens, while its tip is connected with a rod, and thus with the optic-nerve.

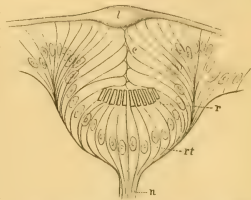


FIG. 1.—Section of simple eye of *Dytiscus* larva, greatly enlarged. *l*, Lens. *c*, Crystalline body, not yet broken up into cones. *r*, Rods. *rt*, Retina. *n*, Optic nerve.

The compound eyes differ from the simple ones by having a large number of corneal lenses, each conveying the light to a single rod and cone. In some (Fig. 3) the crystalline cones are well developed, in others (Fig. 2) they are represented by cells but little modified. Concerning the physiological action of the eyes of Arthropods, there have been several theories, but the one which at present is most in vogue is the "mosaic theory," which supposes that each retinal cell perceives but a portion of the picture, and that by the action of the brain the various parts are put together so that the whole is seen, as a veritable optical mosaic. There are certain difficulties connected with this theory, but our space forbids their discussion.

As a rule the eyes are confined to a well-defined region, that of the head, there being, however, one conspicuous exception, the crustacean *Euphausia*, where on the thorax and abdomen occur organs which are interpreted as having visual functions. In many of the Crustacea simple eyes are found in the young, but all traces of them disappear in the adult.

The auditory organs are far less constant in their position, as can be seen from a few examples. In the Decapod Crustacea they occur on the basal-joint of the inner an-

tennæ; in the closely allied *Mysis*, on the posterior pair of appendages. In the Acrididæ (grasshoppers) the ears are found on the base of the abdomen, while in the Locustidæ (locusts) the auditory organs are on the first pair of legs. In the Crustacea the ear, when found, consists of a sac, more or less completely closed by a membrane, and containing small sand-like particles (otoliths) suspended in a mucous fluid. The inner wall of the sac bears a row of numerous fine hairs, each connected with the extremity of a nerve fibrille. A sound causes the membrane of the sac to vibrate, this in turn sets the granular contents in motion, and these, touching the hairs, convey the impression to the nerves and thence to the brain. In the common grasshopper the ear is of a different type. On either side of the first segment of the abdomen is found a large



FIG. 2.—Section of part of eye of *tipula*. *c*. Crystalline cells. *ct*. Cuticula. *l*. Corneal lenses. *n*. Nerves. *p*. Pigment cells. *r*. Rods. *rl*. Retinula.



FIG. 3.—*A*. Section of eye of cray-fish. *B*. A single corneal lens, with corresponding cone, rod, and retinula, greatly enlarged.

membrane, roughly corresponding to the tympanic membrane of the Vertebrates. Attached to the inner surface of this are two horny processes. A large tracheal vessel is distributed over the inner side of the membrane, and between its walls and the latter a nerve passes to the region occupied by the processes above referred to, and there enlarges into a ganglion, the outer face of which, beset with numerous glassy rods, arranged side by side, is in contact with the tympanic membrane. In the crickets and locusts the ears have an essentially similar structure. In other insects great uncertainty as yet exists regarding the auditory organs. Professor Mayer thinks that the fine hairs on the antennæ of the mosquito have acoustic functions, but this is far from proved.

Regarding the other organs of sense in the Arthropoda, our knowledge is very slight, and all statements are largely a matter of speculation. The hairs which are found distributed over the surface of the body, are frequently concerned in the sense of touch, and possibly sometimes in smell, taste, and hearing as well. The difficulty which attends any attempt at experiment in this direction is the chief cause of this uncertainty.

All Arthropods further agree in the fact that in the ripening of the egg (except in a very few forms) no polar globules are known to be formed. They have also a common mode of egg segmentation; but neither of these points are to be regarded as of



FIG. 5. — Megalops of *Neptunus*.



FIG. 6. — Young *Neptunus* produced from the above by a single moult.

great importance when viewed from a systematic standpoint. Beyond the maturation and segmentation of the egg the Arthropod have but very few embryological features in common; on the other hand, the evidence presented by the development of the insects and Crustacea is such as to be almost conclusive of the distinctness. We have, however, one feature to note in connection with their growth. As we have seen, the Arthropoda are enclosed in a chitinated integument, which forms a firm investment for the body, without provision for any increase in size, to correspond with the natural growth of the animal, and hence, at intervals more or less frequent, according to the size and rapidity of growth, the integument, or rather its outer hardened portion, is shed, and then the underlying skin produces a new and larger external skeleton, to be shed in turn when further increase in size renders it necessary. In connection with this growth in size and consequent shedding of the skin or exuviation most of the Arthropods undergo marked metamorphoses, the result being to produce forms widely differing from the younger stages. Sometimes the changes are effected gradually, slight differences being noticeable at each moult, at other times the differences between two moults being enormous, as shown in Plate I, which represents the changes produced by a single moult in the edible crab (*Neptunus hastatus*) of the Atlantic coast. The only other example which need here be instanced is that presented by the Butterflies, familiar to all, in which a worm-like larva hatches from the egg, eats and grows, occasionally casting its skin to accommodate its increase in size, but without much changing its general appearance, until at last, by a single moult, it passes suddenly into a chrysalis, which presents but a very slight resemblance to the previous larval condition. A period of apparent inaction now intervenes, in our climate frequently lasting through the winter, but beneath the skin of the chrysalis great changes are in progress, and in due season the skin is shed again and for the last time, and the perfect form, the butterfly, is the result. In the pages of this volume many examples of these metamorphoses will be found.

The Arthropoda are usually divided into two classes, Crustacea and Insects, but in nature we do not find such exact classifications as are to be found in books, and there exist many groups of Animals which do not readily fit in any of the accepted classifications. Among the Arthropoda we find such forms, whose position is by no means certain, and which have alternately been regarded as belonging to the Crustacea and to the Insects. Owing to this unsettled condition of our knowledge and opinions, in the present work the Horse-Shoe Crabs and Trilobites, the Water-bears, Scapspiders, and Linguatulina are placed between the Insects and Crustacea, where it is possible they really belong.

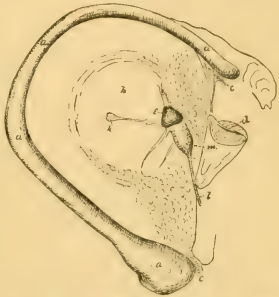


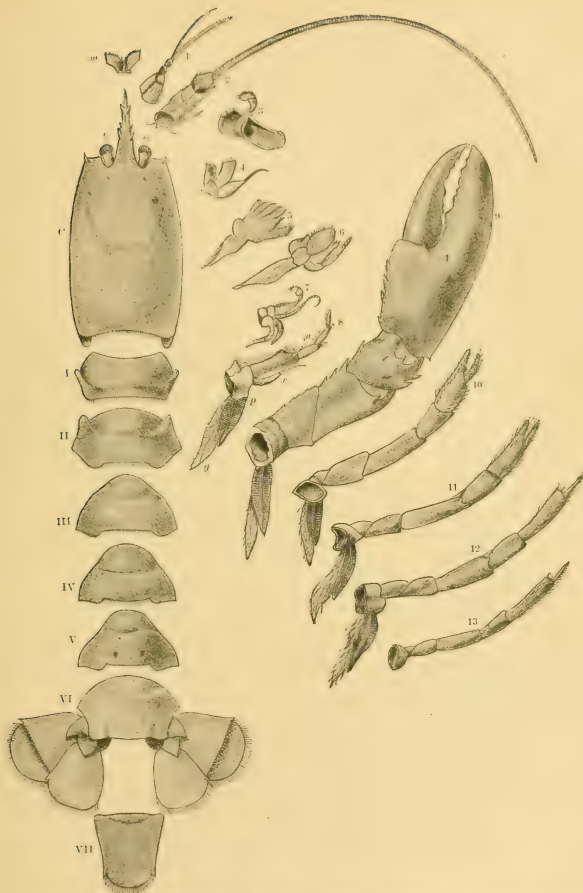
FIG. 4. — Ear of grasshopper, from within. *a*. Thickened rim of (*b*) tympanum. *c*. Muscles. *d*. Spiracle. *e*. Conical process. *f*. Triangular chamber. *g*. Auditory nerve. *m*. Auditory ganglion.

CLASS I. — CRUSTACEA.

The Crustacea as a group are essentially aquatic, and although some of the members live on the land, all require the presence of moisture for the purposes of respiration. Nine-tenths of the known species live in the sea, while the majority of the remaining forms inhabit fresh water, only a very few being adapted for life on the land. In size they vary from forms only to be seen with the microscope to the giant *Macrocheira* of the Japanese Seas, whose legs will occasionally embrace a distance of twenty feet and even more, and the lobster of our own coast, specimens of which have been taken weighing forty pounds. No very reliable or accurate estimates have been made as to the number of existing species, but probably ten thousand is within the limits. This number is much larger than the one usually assigned, but when we recollect that there are about eight hundred species of Decapoda alone described from North America and the West Indies, it will readily be seen that our estimate for the class is certainly within bounds.

The body of the Crustacea is almost universally enveloped in a more or less hardened chitinous integument, in which, in the Barnacles and the higher groups, carbonate and phosphate of lime are deposited, giving this external skeleton much greater firmness. This, though a character of but slight morphological importance, has nevertheless given the name to the class in allusion to the *crustaceous* character of the body walls. Were this external skeleton solid and firm all motion would be impossible, but this is provided for by joints in which no lime is deposited, and which are therefore softer and more flexible. As in all Arthropoda, we can reduce the body to a series of rings or somites, arranged one after another, and each typically bearing a pair of jointed appendages. So far this corresponds with the structure of the insects, but it is to be noticed that in the Crustacea each appendage consists of a basal joint (*basipodite*) attached to the body, and from this arise two jointed branches, the inner being called the *endopodite*, the outer the *exopodite*, the inner and outer feet. In the adult forms of many of the Crustacea but one of these branches persists in some of the limbs of the adult, though in the young the bifurcate character is almost always plainly to be seen. By following through the development we find that it is the outer branch which has disappeared in the adult. In the anterior portion of the body the rings are frequently so completely coalesced that it would be difficult to ascertain their number were it not for the morphological law first propounded by the eminent French naturalist, J. C. Savigny, that each segment of the arthropod body bears but one pair of appendages; a law to which, however, there are several exceptions. The number of segments in the Crustacea varies widely, from the three indicated segments of the larvae of some forms to twenty segments in the Decapoda, and forty-seven in *Apus*, one of the Phyllopods, which, by the way, affords one of the exceptions to Savigny's law, it having twenty-seven thoracic segments bearing sixty pairs of limbs.

As has been said, it is frequently difficult in certain portions of the crustacean body to make out the limits of some of the segments, and especially of those in the anterior part. This is due to two causes: the segments are frequently coalesced so that the sutures are almost obliterated, and partly to the fact that certain segments are so hypertrophied that atrophy of parts of the adjacent somites of a necessity follows.



EXTERNAL ANATOMY OF A LOBSTER.

C, Carapax: 1-VII, Abdominal segments; e, eye; g, gill; m, metastoma; n, endopodite; p, epipodite; x, exopodite.
 1, antennula; 2, antenna; 3, mandibles; 4, 5, maxillae; 6, 7, 8, maxillipeds; 9, big pincer; 10-13, walking feet.

A striking case of this occurs in the lobster, which viewed from above shows the anterior portion of the body covered by a large shield, the *carapax*, with a transverse line. On careful study it is found that this anterior portion, to anticipate a little our account, represents the dorsal portions of the mandibular and second antennal segments, and the impressed line represents the nearly obliterated suture between the two somites. This carapax covers more than the two segments mentioned, and if the segments covered are examined it will be found that the rings are not complete, the upper portion being absent, its place being supplied by the carapax. It is frequently attempted to divide the anterior portion of the body of the Crustacea into head and thorax, corresponding to the same portions of insects, but without any great success, as in nature no such division exists, and the attempts to homologize the appendages of the insects with those of the Crustacea are never productive of any very satisfactory results. Still, the divisions are very convenient, and in this work will be used with functional limits, the head containing those segments connected with the senses and with eating, the thorax, those whose appendages are principally locomotive, while the abdomen embraces the segments behind the thorax. Thus, in the Decapoda the line between head and thorax will come between the eighth and ninth segments; in the Tetradeapoda between the sixth and seventh, etc.

Returning now to the limbs or appendages which we left for the moment, we find other things for consideration. Besides the two branches, exopodites and endopodites, which we have mentioned, the limbs frequently bear a third, the *epipodite* or *flabellum*, and the gills or respiratory organs, of which more anon. The form of the limbs is subject to great variation according to the functions they have to perform, some being the supporters of organs of sense, those around the mouth taking part in the capture and preparation of food, the next group in walking or swimming, while still others play a subordinate part in the perpetuation of the species, either as intromittent organs or as supporters of the eggs. The two anterior pairs of appendages, the *antennulæ* and *antennæ* are always in advance of the mouth, and seem to be chiefly sensory, the ear in many forms occurring on the basal joint of the antennula. The *mandibles*, the first pair of appendages behind the mouth, come next, and are succeeded by two pairs of *maxillæ*, and then the *maxillipeds*, of which in the Tetradeapoda there is but a single pair, in the Decapoda three pairs. Beyond this point in any account of the limbs of the Crustacea as a whole it is difficult to go, and the reader is referred to the portions upon the special groups for information upon this point.

Strange as it may at first sight seem, a true heart is not invariably present in all Crustacea; in certain forms the blood is propelled merely by the motions and consequent changes in the shape of the body, and no central propelling organ exists. When present, the heart consists either of an elongate tube or a short sac directly beneath the integument of the back. From the heart the blood is carried in arteries to

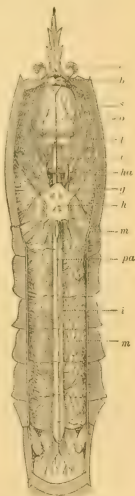


FIG. 8.—Internal structure of lobster, half natural size. *b*, Brain. *s*, Eye. *g*, Gills. *h*, Heart. *pa*, Hepatic artery. *i*, Intestine. *l*, Liver. *m*, Muscles. *o*, Ophthalmic artery. *s*, Stomach. *pa*, Posterior artery.

all parts of the body, and is then collected in *venous sinuses* (spaces between the various organs and muscles, there being no true veins), goes to the gills, and then back to the heart. The blood is either colorless or of a pale yellowish or reddish hue, which is due to the fluid portion and not to the few colorless corpuscles.

With the Crustacea the appendages near the mouth, as has been already indicated, are usually modified for the capture and the comminution of food. After being torn into sufficiently small bits to obtain a ready entrance to the mouth, the substances eaten pass through a short oesophagus into that portion of the digestive tract called the stomach, which in the higher groups is divided into two portions. In the anterior are found three hardened, bony teeth which, moved by appropriate muscles, meet together and thoroughly grind the food. When in a sufficiently fine condition it passes into the posterior and smaller chamber, the passage of the larger particles being prevented by a strainer of stiff bristles. From the stomach the partially digested food passes into a long and straight intestine terminating at the posterior end of the body. A liver, which is always very large with the Crustacea, pours its secretions into the intestine. This slight description of the digestive tract applies to the higher forms, and between them and the degraded Rhizocephala, in which the digestive tract entirely disappears, almost every gradation can be traced. A few of the Crustacea live upon vegetable food, some are parasitic, and draw their sustenance directly from the fluids of the body of their host, while the great majority of the class are scavengers, living on decaying animal matter. The immense amounts of animal tissues which these Crustacea will devour almost surpasses belief. The flesh of a large fish when placed in the sea will wholly disappear in a few hours, all being eaten by these useful forms.

In their manner of respiration the Crustacea present a marked difference from the insects, in that moisture is always necessary. In the lower groups the aeration of the blood occurs at the surface of the body, no specialized organs being developed, while in the higher forms gills are present, and there the principal portion of the oxygenation of the blood takes place. These gills, which are always expansions of the integument, are either borne upon the limbs or the walls of the body immediately adjacent to them, or are limbs themselves, modified so as to expose a large surface to the water. In some cases the gills hang freely in the water, but more generally they are enclosed in special respiratory chambers, which in the Isopoda are formed beneath the hinder segments of the body, and are enclosed by a pair of modified legs which shut together like folding-doors. In the Decapoda the gill-chambers are two in number, there being one on either side of the anterior half of the body. If we examine a lobster, crayfish, or crab, we find that the portion of the carapax immediately above the walking legs is not the wall of the body, but that between it and the true envelope there exists a cavity into which the gills project. This cavity is nearly closed, and in it the gills would have but little chance for exercising their functions were it not for an interesting contrivance for constantly renewing the water in the chamber. At the anterior end of the chamber there is a thin, leaf-like organ which in life is in constant motion, thus forcing the water forward, while fresh water enters from behind. This organ is really the exopodite of the second maxilla, and has received the name *scaphognathite*, or the bailing jaw. In a land crab from the East Indies (*Birgus latro*), Dr. Semper found that by a long life upon the land the gills had become much reduced in size through disuse, and to afford a means of respiration there had developed in the upper portion of the branchial cavity numerous ramified tufts well supplied with afferent and efferent blood vessels, and which can be interpreted only as func-

tional lungs. In other land crabs no such pulmonary organs are developed, and yet it is possible to drown them by a prolonged submergence in the water. We shall recur again to this subject in treating of the Decapods.

The nervous system of the Crustacea, like that of all Arthropoda, usually consists of a large anterior ganglion, or "brain" (supra-oesophageal ganglion), from which two nervous cords or commissures arise, and which, passing back, one on either side of the oesophagus, connect the brain with a series of similar but smaller ganglia lying on the floor of the body; there being typically a single ganglion for each segment of the body: but occasionally we find two or more of these secondary brains united, and the cords which should connect them obliterated. From the supra-oesophageal ganglion nerves go to the eyes and the antennae, in which the organs of sense are most specialized, and hence, as it is through this portion of the nervous system that the animal receives the larger portion of its knowledge of the external world, the supra-oesophageal ganglion may be dignified with the name of the brain. From the other ganglia nerves arise which pass to the muscles, organs, and limbs of the corresponding portions of the body. The foregoing account applies to the majority of the Crustacea, but various modifications are found, and in the adults of some of the parasitic forms no trace of a nervous system has as yet been found.

One of the most interesting subjects connected with the Crustacea is their reproduction, a field which has already furnished many valuable results, but which, nevertheless, has scarcely begun to be worked. A few general features only will be mentioned here, the variations in the different groups being described in their proper place in the succeeding pages.

The eggs of the Crustacea are almost invariably carried by the mother, either attached to some portion of the body (usually the abdominal legs) or covered in a brood-pouch usually attached to some portion of the thorax.



FIG. 9. — Nervous system of lobster.



FIG. 10. — Section of segmented egg of shrimp.

The eggs after fertilization segment more or less completely, there usually being a central portion of the yolk which does not divide. A portion of the resulting cells soon invaginate, and are destined to form the lining cells of that portion of the alimentary tract known as the mesenteron. The place where this invagination took place soon closes up, and on either side the appendages are seen to bud out. These appear at first as simple buds, the pair which are to form the antennae first being seen, and very soon after the antennulae and mandibles arise simultaneously, and then after them, in varying order, the other appendages. These appendages increase in length and become divided into a series of joints, and each, except the first, acquires a two-branched condition. The mesenteron, formed as we have seen, for a time exists without any connection with the exterior, but soon there is a pushing in at each end of the body, and the tubes thus formed unite with that already existing, forming the completed alimentary canal.

The stage of growth at which the embryo hatches from the egg varies even among closely allied forms, there being

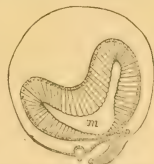


FIG. 11. — Gastrula of euryfish.
a. Abdomen. m. Mesenteron.
p. Proctodaeum. s. Stomodaeum.

several distinct types of development, which, omitting several exceptions, may be here briefly described. The barnacles, Entomostraca, and a few examples of other

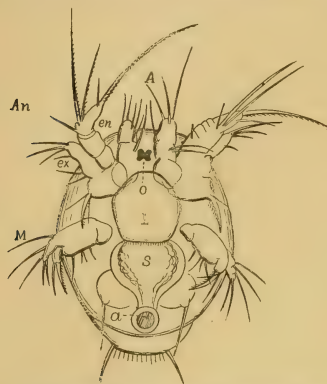
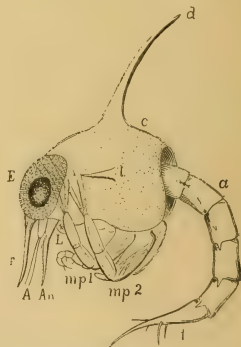
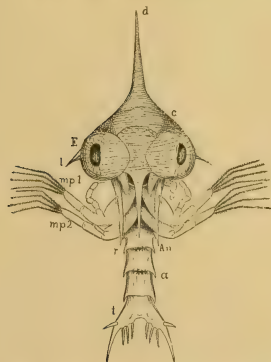


FIG. 12.—Nauplius of *Canthocamptus*. A. Antennula. a. Anus. An. Antennæ. en. Endopodite. ex. Exopodite. L. Labrum. M. Mandible. o. Ocellus. s. Stomach.

groups, hatch when but three pairs of legs are developed. This stage of the young is known as the *Nauplius* (Fig. 12), this term having been applied to one of these larval forms by Otto Fabricius Müller, a Danish naturalist, under the impression that it was an adult. From this the use has extended, until now a larval crustacean with three pairs of limbs, the two posterior two-branched, a single median eye, a large upper lip, and generally an unsegmented body is implied by this term. In another type the young crustacean hatches in the form known as a *Zoea* (Fig. 13), named by Bosc, with the same impression as that to which we owe the term nauplius. The zoea is characterized by the presence of a large carapax, sometimes armed with long spines. The abdominal segments are well developed, but



FIGS. 13 and 14.—Front and side view of zoea of *Neptunus*. a. Abdomen. A. Antennula. An. Antennæ. c. Carapax. d. Dorsal spine. E. Eye. L. Labrum. l. Lateral spine. mp¹. First maxilliped. mp². Second maxilliped. r. Rostrum. t. Telson.

without appendages, while the seven anterior pair of cephalic appendages are present, most of them biramous in character. In the higher Decapoda the zoea frequently gives rise to a *Megalops* (Pl. I., Fig. 5), with very large, stalked eyes, and the complete number of appendages, from which, by a series of moults, the adult form is produced.

In the third type which we have to consider, the young undergo all of these changes within the egg, and when hatched more or less closely resemble the adult, the full number of appendages being formed.

On hatching from the egg the young crustacean usually begins to eat, and with the assimilation of food an increase in size occurs. Now the larva is enclosed in a hardened integument, and so to accommodate this growth, the skin is periodically shed. This exuviation is accomplished in different ways; the skin or shell either splits across between the segments or down the back, and the animal withdraws himself through the opening thus presented. At first the new skin is very soft, but it gradually becomes harder, at last acquiring its proper condition. In the young these ecdyses are very frequent, and are often accompanied by the great changes in the shape and appearance of the larva just described, but as the animal approaches the adult condition the exuviations are less frequent, and the changes less marked.

The classification of the Crustacea has not yet reached a satisfactory condition, but for our purposes the following grouping of the sub-classes may prove convenient: Sub-class I., Cirripedia; II., Entomostraca; III., Podophthalmia; IV., Edriophthalmia.

The Phyllopod division of the Entomostraca seems to represent the central stem around which the other groups are arranged, and with which they are phylogenetically related, though as yet our knowledge is not sufficient to clearly show the lines of descent and the degrees of relationship of the various forms.

SUB-CLASS I. — CIRRIPIEDIA.

The Barnacles derive their scientific name, Cirripedia, from the appearance of their feet, which, as thrust from the living shell, present a marked resemblance to a lock or curl of hair. Regarding their common name, barnacles, some doubt exists, though it probably was derived from the Latin *perna*, a ham; diminutive *pernacula*, from whence the transition is easy to the now current form. Closely connected with the barnacles, in a now extinct folk-lore, are the barnacle geese, and Professor Max Müller has traced

out the myth in its various phases, clearly showing that it arose from a similarity of vernacular names of the bird and of the crustacean. The bird derived its name from its occurrence in Ireland (Hibernia), whence the old form *Anas hiberniculæ*. Then the "hi" was dropped, as is frequently the case among Latin words which find their way into the Romanic tongues, and we have *bernicula*. So, as the names were identical, it most conclusively follows that the animals are one and the same, and so arose the myth, which was current for five centuries, that the barnacles when ripe opened their valves and out came the young barnacle goose. Some of the old accounts may prove of interest.

Bellenden, Archdeacon of Murray, quoting from a Latin history of Scotland (1527), gives this description of "geis genesit of the see, namit clakis": "All treis that are cassin in the seis be proces of tyme first worme etin, and in the small boris and hollis thair of growis small wormis. First they schaw their heid and feit, and last of all they schaw their plumis and wyngis."

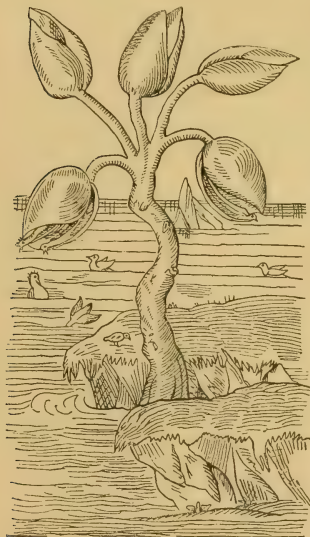


FIG. 15. — Gerard's figure of Barnakles producing geise.

Gerarde, in the Appendix to his "Herball or generall Historie of Plantes" (1633), not only describes, but gives a picture of the whole process, which we reproduce. His description, with a few omissions, is as follows: "We are arrived to the end of our Historie, thinking it not impertinent to the conclusion of the same to end with one of the marvels of this land (we may say of the world). There are founde in the north parts of

Scotland, and the islands adjacent, called Orchades, certain trees whereon doe growe certaine shell fishes, of a white colour, tending to russet, wherein are contained little living creatures; which shells, in time of maturitie do open, and out of them grow those little living foules, whom we call Barnacles, in the north of England Brant Geise, and in Lancashire tree geise; but the other that do fall upon the land do perish and come to nothing." He then goes on to describe in detail the various transformations which he witnessed, saying, "But what our eyes have seene and hands have touched we shall declare." He tells us that when the bird is formed in the shell, the latter gapes, the legs hang out, the bird grows larger, until at length it only hangs by the bill, and finally drops into the water, "where it gathereth feathers and growth to a foule bigger than a mallard and lesser than a goose." In Walton's "Complete Angler" we find the same idea in poetical form, and, finally, in the "Philosophical Transactions of the Royal Society" (1677) Sir Robert Moray has published "a relation concerning barnacles," embodying the same curious idea. These extracts show that the myth had a strong life, for, although contradicted by Albertus Magnus and Roger Bacon, still, so the story runs, the barnacle goose was allowed to be eaten during Lent and on fast days, since coming from the barnacle, a fish, the goose could not be flesh, and hence was not prohibited by the laws of the church.

It was not till 1828-29 that J. V. Thompson showed by their embryology that the barnacles should be classed with the Crustacea. Previous to that time they had been universally considered as belonging to the mollusks, from the fact that they possessed a shell. Even Cuvier, who dissected them, failed to be struck with their articulate characters. Thompson's discoveries were soon published, and at first met much opposition, though their accuracy was soon established.

We may take for our type of the group *Lepas fascicularis* Ellis and Solander, which is well represented in Fig. 16. In this form we have a short, stout, fleshy stalk or peduncle by which the animal attaches itself, and a larger "head" or *capitulum*, in which we find the principal organs of the cirriped. Occasionally, instead of being attached to some marine object, this species of barnacle secretes a float from the cement glands of the peduncle, and thus, free from every other object, is drifted about by the waves. The capitulum is flattened and enclosed by five calcareous valves connected by a tough membrane. On one edge there is an opening through which the feet and the mouth can be protruded at will, but when the animal is disturbed, in go the feet, and



FIG. 16. — *Lepas fascicularis*.

by the aid of a muscle connecting the valves of the shell, all is made close and tight. Removing the valves from one side (Fig. 17) we can see the body, irregularly oval in form, with six pairs of long, feathery feet, each pair being divided in twain nearly to the base. In life these twenty-four feet are in constant motion, creating currents in the waters, by which food is brought to the mouth, which is situated on a sort of prominence nearer the peduncle. On either side of the body are several "filamentary appendages," whose function is not known, though they are supposed to be respiratory, or partially so. On opening the animal we find that the alimentary canal is but little more than a simple tube, the limits between œsophagus, stomach, and intestine being very indistinct. The mouth is furnished with three pairs

of delicate mouth-parts, and over the outside of the stomach occur numbers of simple glands, which are supposed to represent the liver. The nervous system (Fig. 17, C) is upon the regular arthropodal type and needs no special description. Its principal features can be made out from the figure, and its general relations are the same as in other Crustacea. One thing, however, is of interest. For a long time the barnacles were supposed to be without organs of vision, but in 1848 the eminent anatomist, Dr. Joseph Leidy of Philadelphia, found the eyes in the Acorn Barnacle, *Balanus*, and since that time they have been found in many other species. In the form now under discussion there is but a single eye present, and this is found as a small, dark spot in

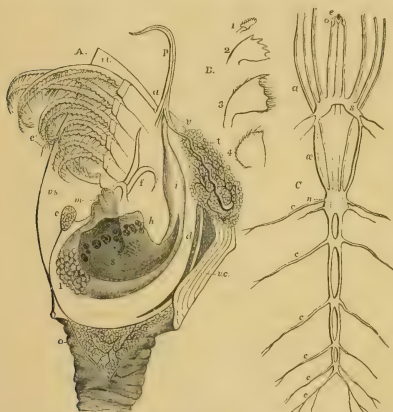


FIG. 17.—Anatomy of *Lepas fascicularis*. A. General anatomy: a. anus; c. cirri; d. dorsal sinus; e. adductor muscle; f. filamentary appendages; h. hepatic openings; i. intestine; l. liver; m. mouth; o. ovary; p. penis; s. stomach; t. testis; v. vas deferens; c.c. carina; r.s. scutum; r.t. tergum. B. Mouth-parts. C. Nervous anatomy: a. antennal nerve; c. nerves to cirri; e. eye; o. optic ganglia; n. supra-oesophageal commissure; s. supra-oesophageal ganglion.

front of the mouth, and completely covered by the integument of the body. Although to a superficial glance this eye seems single, it is in reality composed of two, as is seen from the fact that it receives a nerve on either side (Fig. 17, C e). Of course an eye of this simple character and so enclosed by the skin cannot be of use in distinguishing objects, but since the tissues of the body are very translucent, this eye can recognize the differences between light and shade. Of this ability, a ready proof is attainable; go to some tidal pool where the little white acorn barnacles abound, and there watch the delicate and feathery movements of the cirri, and then suddenly pass the

hand between them and the source of light, and instantly every foot will be withdrawn, only to be put out again after some considerable time has elapsed.

The barnacles are peculiar, in that they have no heart, and even distinct blood-vessels are wanting. The blood flows around between the different organs and muscles, and is kept in motion by the movement of the various parts of the body. There exists a large cavity in the dorsal region, which may be supposed to represent the heart, but no distinct walls are found and no traces of valves exist. In their respiration the barnacles are equally degraded, the whole surface of the body aiding in the aëration of the blood.

The reproductive organs of the barnacles are, in comparison to the rest of the body, very large. In each individual are to be found both male and female parts. The former form finely lobular masses on either side of the body, communicating by fine

branching tubes with a long intromittent organ arising below the vent, at the base of the sixth pair of feet. The ovaries are situated in the peduncle, and superficially resemble the spermogenous organs. The eggs when ripe pass out into the capitulum and there are impregnated. Leaving the egg for the present we will consider a highly interesting subject connected with the reproduction of these animals.

As has been said, the greater portion of the barnacles are hermaphroditic, that is, in each individual are combined the organs of both sexes. Now, one would think that these animals were peculiarly adapted for self-fertilization, but this, so far as our knowledge goes, is not the case. Large numbers of plants have both stamens and pistil (male and female organs) existing in the same flower, and in the older botanical works, especially those with a teleological tendency, attention was called to the adaptations which these flowers exhibited for fertilizing themselves. But subsequent observations show that another interpretation can be placed upon the structure of these organs, and to-day it is clearly proved that in many plants self-fertilization is impossible, and that pollen of another flower is absolutely necessary for the



FIG. 18. — *Scalpellum regium*, with complemental males attached at a.



FIG. 19. — Complemental male of *Scalpellum regium*, greatly enlarged.

fertilization of the ovule and the development of the seed. So with the barnacles. When we study more closely their habits, their anatomy, and the relations of the individuals to each other, we see that there exists a striking adaptation for cross-fertilization. In *Lepus fascicularis*, as in the majority of the barnacles, the individuals occur in colonies placed in close juxtaposition to each other, and so the moderate-sized intromittent organ can be inserted into the shell of the adjoining specimen. In *Acista*, a form which is found on certain corals, the different individuals are usually a little distant from each other, and here we find the intromittent organ extremely elongated, several times the length of the body, so that it can extend from one specimen to its neighbor. Certain barnacles are always found semi-parasitic on larger animals. One species, *Anclasma squaleoides*, makes a sort of burrow in the skin of sharks, and has a seeming provision for cross-fertilization—the animals occur in pairs. There is still a more peculiar condition. The

two genera, *Ibla* and *Scalpellum* are generally solitary; but in these genera we have a queer assortment of sexes. First, we have the normal hermaphrodites; secondly, forms similar in appearance but which are only females, the testicular tissue and the intromittent organ being absent; third, males which are attached to the females, and others (complemental males) which are found only in the hermaphrodites. These males show a great imperfection of development, and always are found living like parasites. In some the mouth and alimentary canal is entirely lacking, some have a



FIG. 20.—Nauplius of *Balanus balanoides*, the frontal horns not fully extended; greatly enlarged.

peduncle, others none. The male generative organs are always developed, but the intromittent organ when present is very short. These forms are found just within the valves, there being sometimes ten complemental males found within the capitulum of a single hermaphrodite. Upon the theory that cross-fertilization is a necessity, the existence of these different forms is readily understood; upon every other it seems to be inexplicable. Nor is our knowledge of cross-fertilization wholly theoretical. Both Dr. Fritz Müller and Mr. R. Bishop have published accounts of witnessing the very act, and the writer would also add his testimony, having seen the operation in the common white acorn barnacle, *Balanus balanoides*.



FIG. 21.—Cypris stage of *Balanus*, enlarged.

We have noticed the curious life-histories which the older writers connected with the Barnacles, but scarcely less marvellous is the true embryology of the group. The fertilized eggs, which we left inside the capitulum, there undergo an unequal segmentation, some of the cells growing around others which are destined to form the alimentary canal. Soon three pairs of legs bud out, the two posterior becoming biramous, and the young barnacle hatches in the form known as a *Nauplius*. This nauplius is characterized by the presence of two frontal horns, a single eye on the under surface of the head, and a long upper lip. All cirriped nauplii have these points in common, but otherwise they present many prominent points of difference in the different groups. In some there is a great development of spines. With its growth the nauplius moults several times, and finally it passes by a single moult into the *Cypris* stage (so called from its resemblance to the adult condition of one of the Ostracoda). The dorsal shield is then replaced by a bivalve shell, hinged above and kept closed by a transverse muscle just below the mouth; a compound eye appears on either side of the primitive single ocellus. A fourth pair of appendages arise behind the mandibles, and behind these are found the rudiments of six pairs of feet. The second pair of antennae disappear, while on the first pair is developed a sucking disc, in the centre of which is the opening of the cement gland. With succeeding moults the posterior feet increase in size, and are used in swimming. The free-swimming cypris stage is not of

long duration; the animal attaches itself by the sucking disc on the antennae, while the cement gland pours out a secretion which more firmly fixes the larva. The succeeding moults are each accompanied with changes in structure, which, slight when considered singly, in the aggregate produce important modifications in the form of the body, resulting at last in the adult condition.

Having now a general idea of the structure and growth of one cirriped we may pass to a consideration of the various forms, noting their differences from the type chosen. We may divide the cirripeds into four orders, *Apoda*, *Abdominalia*, *Rhizocephala*, and *Thoractica*, all of which, with the exception of the *Rhizocephala*, are treated in Mr. Darwin's masterly monograph.

ORDER I. — CIRRIPEDIA APODA.

This group is represented by the singular genus, *Proteolepas* of Darwin, which leads a parasitic life upon one of the higher barnacles, *Alipus cornuta*. Externally it strongly reminds one of an insect larva fastened by two threads (the antennae) to the host. All traces of the cirri are absent. The body is composed of eleven segments, while the mouth is suetorial and so projects from the rest of the body as to give one the impression that it constitutes a distinct segment. Inside of this probosciform mouth are the mandibles, which serve not only as a means of cutting the skin of the host, but as hooks to anchor the parasite firmly in position. From the mouth can be traced a short œsophagus, but all other portions of the alimentary tract are absent, there being no stomach, no intestine, no anus. The nervous system is also apparently absent, and the whole cavity of the body is occupied with the reproductive organs. The antennae, however, possesses the same structure as in the other barnacles. Of the development of the single known species, *Proteolepas birecta*, nothing is known.

ORDER II. — CIRRIPEDIA ABDOMINALIA.

This order is scarcely richer in species than the preceding, but three forms belonging to distinct genera being known, *Cryptophialus* of Darwin, *Aleippe* of Hancock, and *Kochlorine* of Noll. The body has eleven segments, and three pairs of cirri are present, but unlike all other cirripeds these are borne upon the abdominal segments. The labrum or upper lip is very long and capable of independent movement. The lower end of the œsophagus is armed with internal teeth, reminding one of the gizzard of the cricket; the stomach is well developed, while the anus is at the end of the last thoracic segment, just in front of the cirri. The whole body is enveloped in a flask-shaped sac. It was the study of *Cryptophialus minutus* (Fig. 22), which bores into the shells of *Concholepas peruviana*, which first led Mr. Darwin to the study of the cirripeds. This form, as its name indicates, is very small, the largest being not a tenth of an inch in length.

While in many groups of animals the females of widely different families closely resemble each other, and we have to resort to the males for classificatory characters, in the Cirripedia the reverse is the case, for when males exist they are always of an extremely rudimentary character and always live as parasites upon the females. Such is the case with the Abdominalia, where several males are attached to the mouth



FIG. 22. — *Cryptophialus minutus*.

of the female, those of *Cryptophialus minutus* closely resembling those of *Alcippe*, which was formerly placed among the Thoracica, and showing far more resemblance to those of *Ibla* and *Scalpellum* than do the females.

But little is known of the embryology of this group. *Alcippe* hatches as a true nauplius and subsequently passes into the pupa state, closely resembling that of the Thoracica, while in the other forms a free nauplius stage is absent. The embryo is at first oval, but soon two anterior processes, the rudimentary antennæ, appear. The larva next passes into the free cypris stage, creeping about freely within the mantle of the mother. The subsequent stages are not known.

The known species of Abdominalia have the following distribution: *Cryptophialus* comes from the Chonos Islands, Southern Chili; *Alcippe* from the English coast, and *Kochlorine* from the Mediterranean.

ORDER III. — CIRRIPIEDIA RHIZOCEPHALA.

These degraded Cirripeds, in their adult condition, live as external parasites upon the abdomen of the higher Crustacea, and by degeneration have so completely lost every trace of an articulate structure that were we ignorant of their development, their affinities with the Crustacea would not be suspected. In shape they are sack-like, more or less modified in form by pressure between the thorax and abdomen of the host. From one side arises a tubular process which penetrates the host and frequently divides up into numerous root-like branches. This tube is in reality the mouth, and through it the juices of the crab pass into the body of the parasite. Nearly opposite the mouth is an opening through which the eggs pass out. The whole body is enclosed in a thick muscular mantle, which is never calcified. The internal organs are principally reproductive, the animals being hermaphroditic, while the digestive organs are frequently entirely absent. No traces of a nervous system have as yet been found.

When we study the embryology of the group we recognize at once its affinities. From the egg there hatches a nauplius resembling that of the true barnacle in having frontal horns, while the hinder end of the body ends in two points and the mouth and alimentary canal are wanting. After several moults the cypris stage is reached and the larva after swimming freely for a while attaches itself to the abdomen of some crab, and there undergoes the retrograde metamorphosis which results in the degraded adult. The Rhizocephala are usually regarded as the lowest of the Crustacea, but Kossmann, whose account we are following, places them as they are here classified.

Six genera and about forty species of Rhizocephala have been described, but the distinctions between the various forms frequently seem unimportant, and the characteristic which is most emphasized in the diagnoses is the host, it being assumed that the parasites of different species of crabs must of necessity be distinct. Several forms occur in North American waters, but they have not been studied. We figure two species: *Peltogaster paguri* (Fig. 23), which, as its name indicates, is parasitic upon the hermit crabs, and *Lernaodiscus porcellaneæ* (Fig. 24), as attached to the abdomen of a porcelain crab. The roots, which are well shown in the former figure, are said to have the power of growth



FIG. 23. — *Peltogaster paguri*, showing root-like mouth-parts. Enlarged.



FIG. 24. — *Lernaodiscus porcellaneæ*, natural size.

when separated from the rest of the body, and Fritz Müller says that a parasitic isopod frequently eats the body of the root barnacle and then settles down and draws his nourishment through the roots, which under this stimulus continue their growth. The effect of the root barnacles upon their host is to entirely prevent the normal action of the reproductive organs.

ORDER IV. — CIRRIPIEDIA THORACICA.

These forms agree, in having six thoracic segments, usually bearing six pairs of appendages, the abdomen being absent or rudimentary, the body enveloped in a carapax, which is frequently stiffened by a deposit of salts of lime, and are either sessile or mounted on a fleshy stalk or peduncle. This order embraces the great majority of forms and is readily divided into three families: the Lepadidæ, Verrucidæ, and Balanidæ.

FAMILY LEPADIDÆ.—These Barnacles are characterized by the possession of a fleshy stalk or peduncle which in some is very short, in others sometimes over a foot in length. The capitulum is always flattened and the two sides are drawn together by a single transverse muscle. The general characters of the family have already been mentioned in connection with the account of *Lepas fascicularis*, and need not be repeated here. Most of the Lepadidæ are attached only by the tip of the peduncle, the rest of the body hanging freely in the water, but in the genus *Lithotrya* a different habit is noticed. The species of this genus, which are mostly tropical, bore holes in shells, corals, or calcareous rocks, in which they live. These holes are excavated by horny spines and calcified beads upon the extremity of the peduncle, and so far as the evidence goes the boring is simply a mechanical action. One species, *L. dorsalis*, inhabits the Carribean region, the rest living in the eastern seas.

Pollicipes seems to be the most generalized type of Barnacles, a fact which is in full accord with its geological history, it being the oldest genus. The calcareous valves are very numerous, varying in number from eighteen to over one hundred. Two species occur on the western coast of our continent, *P. polymerus* being the common California form. Of *Ibla* and *Scalpellum* we have already had occasion to speak in connection with the reproduction of the Barnacles. A single species of *Scalpellum*, *S. Strömei*, has been found in the deep waters off the New England coast. There are several genera of Lepadidæ in which the calcareous valves of the capitulum are very small or wanting, of which we can only mention *Conchoderma aurita*, which has two tubular earlike appendages on the capitulum, which possibly are of use in respiration, while the more common *C. virgata* is without such appendages. The specimen figured (Fig. 25) is attached to a *Penella*,



FIG. 25. — A Barnacle, *Conchoderma virgata*, attached to a sea-pen, *Penella flexilis*, which in turn was parasitic on a sun-fish.

one of the siphonostomous Crustacea (to be referred to further on), which in turn was parasitic upon the large sunfish, *Mola rotundata*. *Lepas*, the typical genus of this family, is almost invariably attached to floating objects, and, hanging down in the water, sometimes reaches a length (in *L. anatifera*, Fig. 26) of sixteen inches. These are the most common forms in collections, and the species have a world-wide distribution.

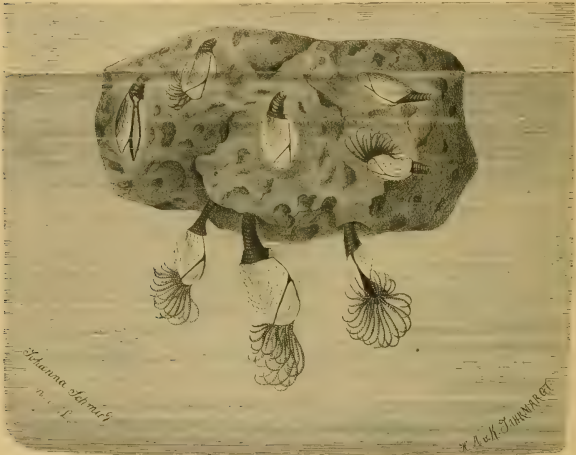


FIG. 26. — *Lepas anatifera*, attached to floating pumice-stone.

FAMILY VERRUCIDÆ.—This family, containing but the single genus *Verruca*, closely resembles the next in being sessile, but differs in having a very symmetrical shell, and the valves closely resemble those of the Lepadidæ.

FAMILY BALANIDÆ.—The acorn barnacles are the most numerous in species and specimens, and we may take the common form of the Northern Seas, *Balanus balanoides*, as our type. This species, which is found encrusting rocks and piles between tide-marks, in form is a white calcareous pyramid, made of six immovably-united pieces, forming an irregular oval ring with the centre filled with four movable valves, between which the animal protrudes the cirri. Inside of the shell we find the animal closely resembling that part of a *Lepas* which is embraced within the capitulum, but with an additional muscle for pulling down the occludent valves and thus more completely protecting it. *Balanus psittacus*, is the largest species, sometimes reaching a

length of nine inches, and in one case three and one-half inches in diameter. It is considered, both by the natives of the west coast of South America and the travellers who have eaten it, a delicious article of food.

Chelonobia is a flattened form which is usually found attached to turtles or Crustacea in tropical seas, the tortoise-shell turtle almost invariably having several attached to his carapax. *Coronula*, with its three species, *diadema* (Fig. 27), *regina*, and *balanaris*, always occurs imbedded in the skin of whales, a habitat which is shared by *Tubicinella*, while *Xenobalanus* affects the shell of Tortoises and skin of Black-fish.



FIG. 27. — *Coronula diadema*, one-third natural size.

Of the Cirripeds the Thoracica alone have been found fossil. The Lepadidæ appeared first, *Pollicipes*, the oldest genus, appearing in the Lias, while the family attained its culmination in the Cretaceous Period. *Verruca* appears in the Cretaceous, while the Balanidæ belong to the Tertiary and Recent times, *Balanus* occurring in the Eocene of Europe and America. Many species have been described by Lea, Conrad, Morton, Holmes, and others from American strata, but from the fact that the opercular valves are usually wanting, it becomes very difficult to recognize the affinities of the species mentioned. The geological history, the structure, and the development as far as known all point to the idea that *Pollicipes* is the ancestral form of the Thoracica, and from it have developed on one side the rest of the Lepadidæ, and on the other the sessile Balanidæ and Verrucidæ.

J. S. KINGSLEY.

SUB-CLASS II. — ENTOMOSTRACA.

BETWEEN the Cirripedia, or barnacles, which we have just left, and the Podophthalmia, or stalk-eyed crustaceans, there are placed, in all systematic treatises, a large number of Crustacea, mostly of minute size, the large majority of them being so small as to require the compound microscope in their study. Beyond the fact that they occupy the intermediate position just mentioned, authorities do not completely agree in their classification. But this difference of opinion arises chiefly from the fact that some consider the divisions Cladocera, Copepoda, etc., as sub-classes equivalent in rank to the Cirripedia and Podophthalmia, while others regard these groups as only of ordinal value, — a view which we are inclined to adopt.

In the Entomostraca the abdomen is almost always devoid of appendages, and, further, is frequently itself reduced to a mere rudiment. But three pairs of morphological limbs function as mouth-parts, while the true limbs show an almost endlessly varied series of form, and the variations in number are nearly as great, all being lacking in the adults of some parasitic forms, while in some of the Phyllopoda the number of appendages exceeds sixty. Some of the Entomostraca have specialized respiratory organs, in others all traces of organs of circulation and respiration are wanting. The Entomostraca almost always hatch from the egg as nauplii. Beyond these few points it is difficult to go; for there is so much variation in the different orders and individuals that but few statements will apply to the sub-class as a whole.

From an economic standpoint the Entomostraca are important only as they indirectly affect human interests by furnishing food for fishes, or, by the parasitic habits of some forms, tending to injure the quality and growth, or even destroy the life of this valuable source of food. The larger forms are somewhat rare, comparatively speaking; but the smaller forms, especially in the ocean, exist in unnumbered millions. No one who has never drawn a surface net in some sheltered bay has any idea of the myriads of Entomostraca in the sea; and should this "surface skimming" be performed on a still night, the phosphorescence adds not a little to the interest of the occasion. While in tropical seas large numbers of animals produce this light, on the New-England coast the greater part is the result of the Entomostraca, though jelly-fishes and Infusoria furnish their share.

In the succeeding account each order of Entomostraca is mentioned, but only the most important families are enumerated.

ORDER I. — COPEPODA.

This order embraces many of our commonest fresh-water Entomostraca, as well as very numerous salt-water forms. In number of species, and in economic importance as well, it stands first. In range of habitat, and in reproductive power, the group surpasses all others among the Crustacea. The animals are mostly small, but are very active; better fitted for locomotion and for a predatory life than are the Cladocera, and so find all waters and all localities suited to one or more of their many species.

Turning to the technical characters, we have to note that the anterior segments of the body are covered with a carapax; the feet are few in number, not exceeding five pairs; a single eye is present, and the segments of the body are well marked. Like most of the Entomostraca, the Copepoda hatch from the egg in the nauplius stage, from which the growth to the adult is gradual, no startling metamorphoses being introduced with the moults.

Of all the Copepoda none is more widely distributed or better known than *Cyclops*, the type of the family CYCLOPIDÆ. It is found in ponds and slow streams all over the world, and is the most common crustacean inhabitant of our drinking-water.

It has a body of a long-oval or pear shape, with a large anterior shield, to which succeed four large segments, followed in turn by four smaller joints, forming a tail, which is terminated by two projections armed with bristles.

In front of the animal appears the small compound eye, the primitive crustacean eye, which is found in a rudimentary form in so many of the higher members of the Crustacea, where it has been functionally replaced by a larger and more perfect compound eye.

The retention of this relatively imperfect sense-organ as the only organ of sight is one among several features which mark this as one of the most primitive groups of Crustacea.

The large, straight intestine, usually filled with food and kept in constant motion, occupies most of the body cavity. By its churning action it keeps the blood in motion, and thus fills the place of a heart,—an organ wanting in this genus, though present in other Copepoda. At the proper season the large ovary may also be seen, and often numerous fat globules, sometimes aggregated into large masses.

Of the appendages the antennules are functionally the most important. They are long, stout, many-jointed, and serve as most vigorous organs of locomotion. The antennæ are much smaller, and the mouth parts, mandibles, and pairs of maxillæ are fitted for biting. There are four pairs of large, two-branched legs, which are used in swimming.

These Copepoda have various methods of locomotion. Most frequently they ply their antennules like a pair of oars, and assist their progress by strokes of the tail, using it as a sort of sculling oar. The exact style of

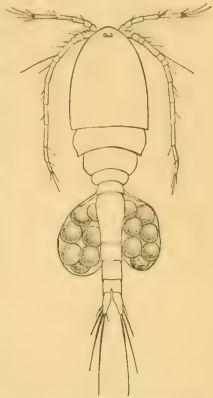


FIG. 28. — *Cyclops fluviatilis*.

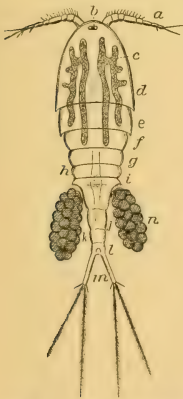


FIG. 29. — *Cyclops canthocarpoides*.
a. Antennule. b. Eye. c. Oviduct.
d. Carapax. e. Ovary.

motion depends upon the size of the antennules. In *Cyclops* they are of moderate size, and are actively used in swimming, though the tail is employed for sudden leaps, and often aids ordinary progress. In the CALANIDÆ the antennulæ are very long—often

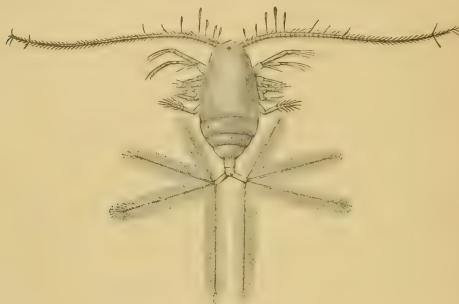


FIG. 30. — *Calanus pavo*.

longer than the animals—and moved by muscles of corresponding strength. Single strokes propel the animal to a considerable distance. This power, and the relatively large size of these members of the Copepoda, give a sort of dignity to their movements. They remain quietly at rest for some minutes, flapping the wing of the maxilla in order to keep up a current of water for respiration, and perhaps to bring small bits of food to the mouth; then suddenly dart a little way, probably to seize some victim, and then return once more to rest. Their vigor is well seen on trying to catch one with the dipping-tube. As soon as the animal feels the rush of ascending water it darts off with a single powerful stroke of the antennules, and so escapes repeated attempts at capture.

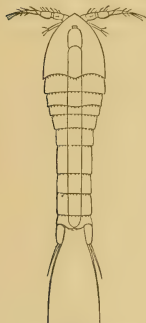


FIG. 31. — *Canthocamptus cavernarum*.

At the other end of the series from *Calanus*, so far as regards locomotion, stands *Canthocamptus*, a member of the family HARPACTIDÆ (Fig. 31), whose antennules are very short, and their action aided by a constant wiggling of the body in locomotion making their motion almost worm-like.

Cyclops, both in structure and habits, stands between these extremes. It is usually found, like *Calanus*, in the free water, though, like *Canthocamptus*, it may burrow in among weeds and vegetable d bris. Often it lies suspended in the water, at rest save for the fluttering of the maxilla, or it may rest by clinging to some support. It may move slowly and steadily by rapid strokes of its thoracic feet, or dart an inch or more by sudden strokes of its antennules. These movements seem to catch the prey, which consists of rotifers, Infusoria, other Crustacea, in short, any animal not too large

or too active to escape its attack. The intestine is often filled with vegetable matter, but this appears to be eaten mainly if not wholly for the sake of the animals it contains. The cellulose seems to be unchanged by the intestinal juices of the animal. It not only eats these minute creatures in the mass, but can single out and hunt down its prey. An interesting study may be made of a *Cyclops* placed in a glass containing, say, *Paramecia*. The Copepod may hurry about, darting from spot to spot, surprising its prey, or it may stealthily swim about by means of its thoracic feet, and so creep up within reach of its food. For minutes together it will remain at rest, until the smaller animals are collected about it, then pounces upon one and quietly devours it, and looks for new prey. But it does not depend solely on hunting. It will, especially in confinement, burrow in decaying vegetable matter, and there seek its food; and a decaying animal is always haunted by these Crustacea, though probably more for the Protozoa collected about it than for the decaying flesh itself, although that may be eaten.

The development of *Cyclops* and its allies shows their primitive nature, indicated also by their eye, carapax, segmentation, and appendages. They hatch from the egg, as a nauplius, a tiny creature with oval, unsegmented body, a straight intestine, a median eye, like that of the adult *Cyclops*, and three pairs of locomotor appendages representing respectively the antennulæ, antennæ, and mandibles of the adult. This larval form is of great interest because of its constant recurrence among the Crustacea. No equal group in the animal kingdom combines so great diversity of form with unity of fundamental structure and development as does the class of Crustacea. The nauplius larva is one of the great bonds of union in the class. Barnacles, Cladocera, Copepoda, prawns, and many other diverse forms have the egg at this stage, and in other groups it is clearly indicated as a stage in the development of the egg.

The changes in passing from nauplius to adult in the *Cyclops* are of the simplest character. New segments and appendages are added to the rear of the nauplius, and their front appendages are modified to serve their permanent uses. These changes are effected by very numerous moultings.

Small as the Copepoda are individually, they are of no little economic importance. This importance they reach through their enormous reproductive powers. An old *Cyclops* may produce forty or fifty eggs at once, and may give birth to eight or ten broods of children, living five to six months. As the young begin to reproduce at an early age, the rate of multiplication is astonishing. The descendants of one *Cyclops* may number, in one year, nearly 4,500,000,000, or more than three times the total population of the earth; provided that all the young reached maturity, and produced the full number of offspring.

These animals thus appear in immense numbers, and their multitude compensating for their small size, they are of great value as a fish-food. They form the main food of most of our fresh-water fishes while young; and some adult forms, like the *Coregoni*, feed mainly on them. The shiners, too, which serve as food for so many larger fish, derive much of their nourishment from these Crustacea. Insect larvæ, too, find them an important item in the bill of fare.

In the sea the Copepoda are of still greater importance. Hundreds of square miles of water in the Atlantic Ocean have been seen colored red by these innumerable swarms. At such times the fish gather in great numbers to feed on the Crustacea; and even whales find abundant nutriment from these tiny creatures, whose numbers more than make up for their minuteness. Whalers are sometimes warned of the probable presence of their game by the appearance of these swarms of Crustacea.

A connection still more important exists between these Crustacea and the herring and mackerel fishery of the coasts of Scotland and Norway. The appearance of these fish on the coasts has been found to accompany the presence of innumerable multitudes of the *Calanus* and other genera of these Copepoda. No other order of Crustacea can therefore compare in economic importance with this. The smallest pools and ditches swarm with them. Wherever life may find a lodging in the water there they are found, ready to become the prey of all higher animals; ready, too, by their surprising rapidity of reproduction to keep their number full. Without them the life of the fresh-water fishes would be almost impossible; and, lacking their innumerable swarms, the schools of herrings and other sea-fish would hardly be able to exist.

A few forms of this group demand special notice in addition to those already named.

One of the marine genera, *Sapphirina*, belonging to the CORYCÆIDÆ, is among the most beautiful of animals. It is large, — nearly a quarter of an inch long, — and is broad and flat in shape. Below the transparent cuticle it possesses a layer of cells from which it gives off flashes of light. This power it shares with numerous other animals, surpassing them in the brilliancy of the light, and in the variety of the colors. While most such animals shine by night, *Sapphirina* shines by day. As one looks into the calm sea he may catch sight of brilliant flashes of color in the water beneath him, — purple, sapphire blue, gold, or green, or other hues. The brilliancy may also vary from the softest to the intensest and most vivid tint. Imagine a diamond shining with its own light, and flashing all colors at will, and one may get a faint conception of this jewel of the sea. Like so much of the beauty of the living world, this power of light-emission is connected with the mutual attraction of the sexes, and is possessed by the males alone.



FIG. 32. — *Sapphirina*.

The families of Copepoda are some twelve in number, and embrace a total of about four hundred species, as at present known. But the field is far from exhausted. Almost nothing is known of any except the European species. The American forms have scarcely been touched, while of the rest of the world the Copepoda are an unknown quantity. No field to-day will afford the investigator more novelties than this group of Copepoda.

ORDER II. — SIPHONOSTOMATA.

By far the greater majority of parasitic animals belong to the Arthropoda. Land animals are infected with parasitic insects, and the aquatic vertebrates are abundantly supplied with guests and parasites from the class of Crustacea.

The parasitic Crustacea, like the insects, mainly belong to one order. A few parasites are known among the barnacles, and a few scattered forms from other groups; but the Siphonostomata are all parasites, in the broad sense of the word, and the group contains very numerous forms of these unbidden guests.

The grades of parasitism in the order are very various. Some species are commensals, living in digestive tract or gill-sac, but feeding only on the food of the host, not on his tissues. Others, though true parasites, are locomotive, attaching themselves to their prey and sucking his blood, but not permanently residing upon him. Others still are

more permanent ietoparasites; still others are endoparasites, living imbedded in the body-cavity or tissues of the host, and living on his blood and lymph. Such forms are often distorted in growth far from the ordinary crustacean type. Nothing can remind one less of a crab, or the nearest allies of the Siphonostomata, the Copepoda, than the misshapen forms of the *Lernæocera* or *Hæmobaphes*. Other forms are less widely separated from the usual type of Crustacea, and remind one of distorted and ill-shaped monstrosities; while the temporary parasites are possessed of well-developed appendages, and in all respects conform to the usual type. We have, then, all grades of structure, all the modifications which can be induced by a parasitism here displayed on a scale, and with a completeness which no other group in the animal kingdom affords. The parasitic insects are too little altered in structure, the parasitic worms are all too profoundly modified to give the range of this order. Again, development here shows the connection of the various forms. However unlike the crustacean form the adult may be, the larva always belongs to the nauplius type, and thus indicates the real affinities of its parents.

The hosts of these parasites are as various as their forms. Fishes of all kinds, whales, mollusks, worms, and ascidians are all provided with these guests. As on land almost every species of bird or mammal has its own parasitic insects, so in the water almost every species of fish or larger invertebrate has its parasitic Siphonostomata. Numerous varieties of parasites often infest a single host. The haddock, for instance, has more than a dozen kinds of parasites, some attached to the skin, others to the fins, others still to the gills, or to the skin of the mouth, or imbedded in the muscles. Other fishes have nearly as many forms; and careful study would, no doubt, vastly extend the number for all sorts of fishes. They attach themselves to the skin of worms or Crustacea, — to the gills of the latter group, — burrow in the flesh of sea-snails, and suck the blood of the cuttle-fishes. Some forms live in the gill-sac of ascidians, either as commensals or as true parasites; and, finally, star-fishes, jelly-fishes, and corals are not exempt from these omnipresent pests.

From these parasitic habits these forms have acquired the vulgar name of "fish-lice," and the order itself is called, by some authors, Epizoa, for obvious reasons. Though closely allied to the preceding order, and, in fact, by some authors united with it, the Siphonostomata seem to be sufficiently distinct to be entitled to a distinct order. Forms like *Caligus* closely resemble the Copepods; but the more typical species of these parasites have undergone a most marvellous retrograde metamorphosis, losing almost everything which could be used as proof of their proper position in any scheme of classification were the adults, and especially the females, studied, the larval stages and the males being ignored.

We will begin the series of parasites with *Argulus*, — a temporary parasite, living on the blood-plasma of fishes drawn from the blood-vessels of the gills, but capable of leaving one host for another, and of maintaining an independent life for a considerable time, living apart from the host as long as a week or ten days after it has filled itself



FIG. 33 — *Dineutauru* form.

with blood. Indeed, if one may judge from specimens kept in aquaria, it seems to prefer the free life except when hungry. *Argulus* (the type of the Family ARGULIDÆ through which the Siphonostomata are connected with the Phyllopoda and Ostracoda) has a flat body, oval in outline, with a bilobed abdomen, four pairs of two-branched swimming legs, besides the antennæ and mouth-parts. On each side of the mouth is a large round sucker, by whose aid they attach themselves to the skin and gills of the fishes on which they prey. They possess pointed mandibles, through which they obtain the blood, and have, besides, a median needle-shaped organ, probably connected with poison-glands, by which they may pierce the skin of the host, and by the poison stimulate the flow of blood. There are two large eyes, and the antennæ are present. So highly organized an animal—one so well fitted for an independent life is hardly a true parasite. It is parasitic at times, and when its sacculated intestine is filled with blood may or may not return to a free life.

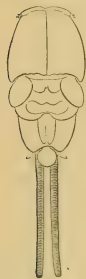


FIG. 34.—*Pandarus*.

A second group of the Siphonostomata contains the CALIGIDÆ. Here belong very numerous species of fish-lice. These have still well-developed appendages, but they are fitted for clinging to the host rather than for swimming, and the forms of *Caligus* and allied genera are sessile though capable of locomotion. They have a sucking proboscis, which encloses the mandibles. They live, mainly attached to the gills of various fishes, on whose blood they live. They may often be found by separating the lamellæ of the gills. Here also belong the genera *Pandarus* and "*Nogasus*," which we illustrate. The latter genus is very doubtful, the individuals being in all probability the males of forms assigned to other genera. Both forms are parasitic on fishes, the individuals figured being attached to Atwood's shark (*Carcharodon atwoodi*).



FIG. 35.—*Nogasus latreillei*.

In *Dichelesthium* and its allies, which form the family DICHELESTHIIDÆ, degradation is carried a step further. The limbs are often aborted so that locomotion is possible only by bending the body. Their habits are much the same as those of the preceding group.

In the family LERNÆIDÆ (*Lernæa*, *Lernæonema*, *Penella*, *Hæmobaphes*, and related forms) the effects of parasitism are carried much further. The segmentation of the body is scarcely marked, the limbs are stumpy projections, and the head is armed with projections which aid in fixing the animal to its host. They are rather worm-like than crustacean in appearance. They live attached to the skin or gills of fishes of all kinds, or in some of their species buried in the muscles of their victim. The males are not parasitic, and are of the usual crustacean form, and the young are *Cyclops*-like. The distorted form of the adult female is reached after the parasitic life is begun.



FIG. 36.—*Hæmobaphes*.



FIG. 37.—*Lernæonema radiata*.

In the LERNÆOPODIDÆ, the last family we have to mention, embracing *Lernæopoda*, *Diocus*, and *Anchorella*,

the degradation of form is still further carried. These misshapen, distorted creatures resemble nothing but the uncanny figures of a nightmare. Small as they are, they arouse in the spectator an involuntary feeling of disgust that such abortions should be found in the group of animals. By what law of nature it follows that parasites should pay for their habits by their loss of beauty and symmetry of form, it is perhaps hard to say, but the fact is undoubted. Wholly apart from a knowledge of their habits, these and most other parasitic forms of animals awaken feelings of disgust. Very few are even neutral æsthetically; fewer still are even moderately beautiful, and those are of the less truly parasitic forms.

In many of these parasitic Crustacea the males are much smaller than the females, — so-called pigmy-males, — and are far less numerous. The females, as is the case in most parasites, produces enormous numbers of eggs.

The development for a time is essentially similar to that of the preceding order. The eggs are carried in egg-pouches (shown in the figures of *Dinematoura*, *Pandarus*, *Hæmobaphes*, and *Lernæonema*), and from them hatch true nauplii. After hatching, the young pursues a type of development peculiar to the family to which it belongs; but in all cases it is the female which undergoes the most extensive metamorphosis, the males diverging but little from the normal crustacean type.

ORDER. III. — OSTRACODA.

As in many another group of minute animals, we have to turn to Europe and European forms for a knowledge of the one now before us, for the reason that these forms have been almost entirely neglected by our own observers, who have had larger, but no more interesting, animals to study and describe.

The Ostracoda are generally very small, and have hard (and frequently calcified) bivalve shells, which often are so opaque that only the most indistinct views can be had of the internal structure without the aid of the somewhat delicate operation of dissection. This bivalve shell is usually ornamented, and by the peculiarity of this ornamentation, as well as the structure of the internal portions, are the species recognized. In the fossil forms the former group of characteristics alone can be used. Some of these markings are produced by the attachments of strong adductor muscles, which pass from one valve to the other, and which by their contraction close the shell.

The shells of the Ostracoda are usually lenticular or reniform, and frequently one end is a little larger than the other. On removing one of the valves the internal structure can be made out with little difficulty. Only seven pairs of appendages are present; the two pairs of antennæ are large, extending beyond the valves, and with their long fringes of hairs are well adapted for purposes of locomotion, in which they are the principal organs. The mandibles are strong, and the mandibular palps are well



FIG. 38. — *Penella filosa*, bearing a barnacle, *Conchoderma virgata* (see also p. 19).

developed. The four remaining appendages are one or two maxillæ, and three or four ambulatory limbs. These variations in number are due to the fact that one of the



FIG. 39.—*Cypris fusca*, enlarged. *a*¹, Antennula. *a*², Antenna. *c*, Telson. *d*, Maxillæ. *e*, Eggs. *f*¹, First pair of feet. *f*², Second pair of feet. *g*, Gill. *m*, Mandible.

members functions as a second maxilla in some forms (*e. g. Cypris*), while in others, as *Cythere*, the same member appears as one of the locomotive series.

The various divisions of the alimentary tract are not well marked. In the anterior portion there is a gastric mill slightly resembling that of the lobster and other decapods, but more strongly recalling the somewhat similar structure in the Isopoda. Behind this mill arise a pair of tubes to which has been ascribed a hepatic function. Some forms are without a heart, while in others that organ is short, and has three apertures. The nervous system, so far as it has been studied, consists of supra and infra-œsophageal ganglia, and a chain of four thoracic ganglia,

from which the ambulatory limbs and genitalia are innervated.

The food may be either animal or vegetable, the latter being taken as well for the animals entangled in it as for the protoplasm of the plant, for the cellulose is here, as elsewhere, unaffected by the digestive juices.

The complete protection afforded by the shell confers peculiar habits upon the Ostracoda. They scramble about clumsily but rapidly, when undisturbed. Their heavy shells are somewhat of an impediment to graceful locomotion, while the small antennæ are not strong enough to prevent a kind of wobbling in the gait, which sometimes has a ludicrous effect. When disturbed they make no attempts at resistance or escape, but the feet and antennæ are quickly drawn in, the valves close, and the animal, relying on the protection afforded by its hardened shell, sinks to the bottom.

The Ostracoda have about the same value, in an economic way, as any other group of Entomostraca, but their comparatively small size and numbers make them less important than the Copepoda. They seem able to maintain themselves when other Crustacea fail to do so. At least it frequently happens that they are the sole crustacean inhabitant of a small pool, and a great number of Ostracoda usually means a paucity of other forms, while other similarly situated puddles may support a more varied entomostracan fauna.

The living forms are mostly small, averaging about a twentieth of an inch in length, though a few members of the group are larger, reaching a length of a quarter of an inch. The fossil forms sometimes acquire greater dimensions, many being as large as a good-sized bean, and some even measuring three inches in their greatest dimensions.

As will be seen from the foregoing, there is no group among the Entomostraca, with the exception of the Siphonostomata, which departs more widely from the regular crustacean type than does this order of Ostracoda. The bivalve shell gives the animal a very molluscan appearance, and the animals, especially the fossil forms, were long referred to that group.

There are six well-marked families in the order, the first two of which have the antennæ simple, the remaining four families having them two-branched.

The first family which we will mention is the CYPRIDIDÆ, so called from its most prominent genus *Cypris*. The family is readily distinguished from the next by having two pairs of ambulatory feet and two pairs of maxillæ; the heart is absent, the eyes simple (in *Bairdia* they are absent). The species are found in both salt and fresh water, and are distributed in all parts of the globe. *Cypris* is a small form scarcely exceeding a twentieth of an inch in length; but, notwithstanding its minuteness, it has a highly creditable ancestry, for forms usually referred to that genus are found in the Silurian rocks. The animal swims by means of its antennæ, which are protruded from the shell for that purpose, but as frequently the same organs are used in a mode of locomotion best described by the term scrambling. The antennæ are aided in the latter method by the hind legs and by the abdomen, which is forked at the extremity, and is used as a lever to push the animal forward. The smaller antennæ have chiefly sensory functions, while a membranous portion of the maxillæ by a constant motion keeps up a continual current of water through the valves, thus aiding in respiration. *Bairdia*, another genus of this family, extends back to Silurian times.

The family CYTHERIDÆ likewise lacks a heart; the shell is thicker and stouter than is the case with the Cyprididæ, while there is but one pair of maxillæ and three pairs of ambulatory feet. About twenty genera, with numerous species, are known.

The four remaining families are less important, and may be dismissed with the mere mention of their names: HALOCYPRIDÆ, with three genera, CYPRIDINIDÆ, with nine and POLYCOPEIDÆ and CYTHERELLIDÆ, with a single genus in each.

The young Ostracoda hatch from the egg as a modified nauplius with three pairs of appendages, but possessing the bivalve shell of the adult.

ORDER IV.—CLADOCERA.

This group includes mostly small fresh-water Crustacea, which are enveloped in a bivalve shell, and which have the antennæ fitted for locomotion. Few salt-water forms are known, but almost every body of fresh water supports its myriads. Open lakes, ponds, the weedy margins of ponds and streams, marshes, muddy bottoms of waters, and temporary pools, all have their population largely made up of members of the Cladocera, whose structure is frequently modified to correspond with the habitat.

We can best arrive at a knowledge of the structure of this group by a study of the anatomy of *Daphnia*, one of the most common forms in fresh water.

Anatomically *Daphnia* is divided into a head and a body, the latter being enclosed in a large bivalve shell. In the head lie the brain, liver-tubules, and eye, the latter organ with its large body of pigment being the most conspicuous structure. The eye is freely movable by means of three pairs of muscles, and is connected with the optic ganglion by numerous nerves. To the sides of the head are attached the large two-branched antennæ, from which the order gets its scientific name, the antennæ being compared to the branches of a tree (*κλάδος*, a branch, and *κέρας*, a horn). The surface which these antennæ present to the water is greatly increased

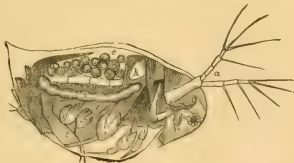


FIG. 40.—Anatomy of *Daphnia pulex*. a. Antenna. e. Eggs. h. Heart. i. Intestine. t. Telson. 1, 2, 3, 4, 5. Five pairs of legs.

by the long plumose hairs with which they are covered. The style of motion of the various species of the Cladoceera largely depends upon the size and mode of handling these organs. In the Daphniidæ, where they are large, the animal usually moves in a somewhat dignified manner by the slow strokes of the antennæ; in the Lynceidæ, where they are small and moved by powerful muscles, the motion is either a hurried, toddling scramble, curiously suggestive of indecision, or, in the smaller and more active forms, it becomes a rapid and decisive darting about. Each genus is characterized by its own style of locomotion, and the motion is often varied with the species, so that the experienced observer can frequently identify the forms in an aquarium with the naked eye, even when but a fiftieth or even a hundredth of an inch in length.

Resuming our anatomical account, the head also bears the antennulæ, fringed with sense-hairs. These organs are brought down to the edges of the valves, so that they may take cognizance of whatever passes into the shell cavity. The large shell is but an enormous development of the integument of the back of the head, and consists of two layers, between which there is provision for an extensive circulation of the blood. The upper portion of the shell cavity serves as a brood cavity, while the adjacent portion of the valves develops the ephippium, to be described further on. The shell is marked with lines and dots, the pattern varying with the species.

The slender body terminates in an abdomen which is bent forward and ends in two claws, and is further provided with a row of spines on each side. This terminal joint is very useful to the animal; it keeps the valves free from extraneous matter, kicking out any unwelcome particle which may have obtained entrance, and serves as a powerful lever in case the animal be caught. To the under side of the body are attached five pairs of legs, all completely covered by the shell. These are broad, flat, and leaf-like, composed of several lobes and furnished with numerous hairs. The largest lobe of the first four pairs is scoop-shaped, with the convexity forward, and with the outer edge thickly set with long hairs, which reach to the inner surface of the valves. These legs move together, backward and forward, and so keep up a constant current of water through the valves, which serves for respiration, and also brings the food. The fifth pair of legs is of a different shape, and is attached to each other along the middle line, and flap like a pair of wings, but in reverse direction to the other legs. The use of this arrangement will appear when the mouth-parts have been described.

The mouth lies just within the edge of the valves. It is guarded below by the long, tongue-shaped lower lip, which is normally pressed up against the lower side of the body. Here are the two mandibles, whose grinding surfaces are rubbed together to triturate the food. Just behind them are a pair of maxillæ, short, hand-shaped organs, which serve to thrust the food between the mandibles.

The mode of obtaining the food is as follows: The first four pairs of legs flap vigorously, and propel a current of water through the shell cavity from front to rear. Just at the edge of the valves lie the small antennæ, which take notice of any large or unwelcome particle. When such an intruder is perceived, the valves close and the motion of the legs stops. The fifth pair of legs, working in a direction opposite to that of the others, creates a sort of whirl in the water, and directs a current upward, which passes between the legs forward to the mouth. The particles of food are thus stored up in this space until the mouth is ready for them, when the lower lip is depressed, the mouth opens, and the maxillæ push a quantity of food between the mandibles. In a good locality a large amount of food will be seen as a dark mass between the legs awaiting

its turn to be eaten. These creatures are omnivorous. Infusoria, rotifers, eggs, and embryos of small animals, diatoms and other algæ, vegetable *débris* of all kinds are acceptable. The sole condition is that the food shall not be too large to enter into the cavity of the shell. The animals are not without taste, as may be seen by feeding them with carmine. At first your Daphnid seems to rejoice in the abundant food-supply, flaps its legs vigorously, and accumulates a mighty supply between them; but as soon as it has tasted the unaccustomed viand its mood changes. It works its œsophagus backward, reverses the action of its jaws, spits out the food, and with the terminal claws on the tail carefully scrapes out and kicks from the shell cavity the carmine, and even cleans out its mouth with the same implements; then sulks and refuses to draw in a current of water laden with such particles.

FIG. 41. — *Acanthocercus*, enlarged.

The Cladocera have an extraordinarily great power of reproduction. All through the summer they produce brood after brood of "summer-eggs," which are simply buds detached while still in the condition of a single cell, and resembling eggs in all external particulars. They develop, however, without fertilization, while the true egg will not do so. These buds or summer-eggs are carried in a brood chamber formed by the dorsal part of the valves. This varies greatly in size and shape in different genera. In the *Lyneceidæ* it is small and imperfectly closed, and rarely contains more than two large eggs. In the *Daphnias* there are often a dozen or more eggs, — sometimes as many as forty or fifty, — which are enclosed in a much more perfectly closed brood chamber, and nourished by fluids excreted by the mother into this cavity. The young develop directly, without metamorphosis, and hatch in the form of the parent. They remain for a day or two in the cavity after hatching, while the shell hardens and the muscles gain strength. They are at this time quite active, and cause much trouble to the parent in keeping the numerous brood in the cavity. Some lively young one must always be kicked back — being too hasty in his attempts to see the world for himself. These broods of summer eggs are produced in rapid succession, and as the young begin to reproduce when only a few days old, the rate of multiplication is very great.

I have seen pools of water red with *Daphnias*, giving the appearance of bloody water. Such phenomena used to be terrible portents to European peasants, foretelling any sort of coming disaster. The water becomes fairly thick with the animals, and all these thousands and millions of beings come into life in a very few weeks.

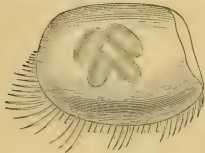


FIG. 42. — Ephippium of *Acanthocercus*.

When the the pools begin to dry up, or, in permanent bodies of water, when winter approaches, a new mode of reproduction comes in. Instead of what may be called neuter-females, true males and females are produced from the summer-eggs, and from the female are produced two true eggs. These are enclosed in a hardened part of the shell, called the *ephippium* or saddle. This consists of the dorsal and lateral parts of both valves, which become hardened and opaque, and when the moult takes place these separate from the rest of the shell and unite their free

edges to enclose the eggs. In this case the eggs lie until spring or wet weather causes them to develop. The parent does not necessarily die on producing these eggs, but may return to the formation of summer-eggs. The deep or open water forms of *Cladocera* live, as a rule, through the winter, while the shallow water forms, and those inhabiting temporary pools, depend on the winter-eggs for the preservation of the species from year to year.



FIG. 43. — *Evadneopsis*, enlarged. *g*. Brain. *h*. Heart.

This order is divided into two sub-orders, *Gymnomera* and *Calyptomera*. The first is characterized by a small shell, not enclosing the limbs, the legs small, the respiratory appendages rudimentary. It embraces the families *PODONTIDÆ*, with two genera, in which the abdomen is short and enclosed in the shell, while the antennulæ lie close to the head; *POLYPHEMIDÆ*, which has the abdomen elongate and free, and the antennulæ exsert and free; and the *LEPTODORIDÆ*, which has six pairs of ambulatory feet (the other families having but four pairs), the abdomen greatly elongate and segmented, while the respiratory organs are absent. *Leptodora* is one of the most *outrè* of the *Cladocera*.

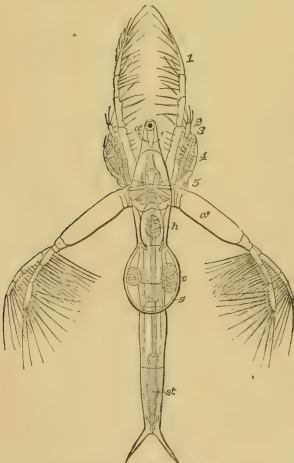


FIG. 44. — *Leptodora hyalina*. *a'*. Antennulæ. *a''*. Antennæ. *e*. Eggs. *h*. Heart. *s*. Shell. *st*. Stomach. 1, 2, 3, 4, 5. Legs (sixth pair not shown).

A rudimentary shell is present only in the female. It grows to be more than an inch in length, and is found in the open water of our great lakes as well as in Europe.

In the second sub-order, Calyptrona, the shell is well-developed, enveloping the limbs, and the ambulatory feet are broad, lamellar, and indistinctly segmented. The lowest family is the LYNCEIDÆ, which has a short oval heart, a long, slender, convoluted intestine, very large antennæ, both branches of which are three-jointed; and the legs, of which there are four or five pairs, are dissimilar, the hinder pair being the broadest. There are about nine or ten genera, the species of which are very small, few attaining a length of a twenty-fifth of an inch. They are mostly inhabitants of weedy shores and bottoms of the shallower parts of lakes and ponds. They are far less abundant than the *Daphniæ* in temporary pools—a fact, probably, due to their less perfect ephippium. But favorable localities swarm with them, swimming from weed to weed, burrowing about in vegetable *débris*, or rapidly whirling about on the calm surface.

In the DAPHNIDÆ the heart is the same as in the last family, the intestine is short and straight, one branch of the antennæ is three-jointed, the other four, while the pairs of ambulatory feet vary in the different genera, of which there are nearly twenty, from three to six. Of *Daphnia*, the typical genus, we have already spoken at considerable length. *Bos-*



FIG. 45. — *Bosmina striata*.

mina is a form closely allied to *Daphnia*. It is a beautiful genus, having the antennulæ very large and firmly attached to the head, curving downward and backward like the tusks of a walrus. The species are very small and unusually transparent, so that the microscope reveals at once their whole anatomy. *Hyaleodaphnia* is characterized by having the front of the head greatly produced.

The last family is the SIDIDÆ, which has an elongate heart, a short, straight intestine, and six pairs of similar, lamellar legs. It

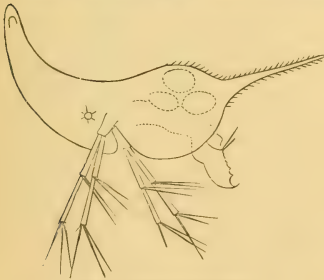


FIG. 46. — *Hyaleodaphnia kerusses*.

contains eight genera, of which *Penilia*, *Sida*, and *Latona* are the most prominent.

The economic value of the Cladocera rests upon their astonishing fertility. Their numbers make up for their minute size, and they form no unimportant element in the food of our fresh-water fishes—the smaller feeding greedily upon them, and as these in turn furnish food for the larger forms, the importance of the Cladocera and the Copepoda can readily be seen.

E. A. BIRGE.

ORDER V.—PHYLLOPODA.

It is seldom that an ordinal name is more appropriate and more descriptive than that applied to the group now to be discussed, for the term Phyllopoda, leaf-footed, is at a glance seen to be applicable in the highest degree to these beautiful and interesting forms. Frequently they are considered as a sub-order of an order Branchiopoda, the other divisions of which are the Ostracoda and Cladocera.

In all the Phyllopoda except the Branchipodidæ the body bears a large carapax, which in the Apodidæ covers the anterior portion of the body in a manner strongly suggestive of that found in the lobster and higher Crustacea, while in the Limnadi-

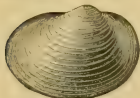


FIG. 47.—Shell of *Estheria helfragel*, enlarged three times.

adæ this armature takes the form of a bivalve shell, the two halves being united by a hinge and closed by an adductor muscle, as in the Ostracoda. This bivalve shell, into which all the members can be drawn, closely resembles that of certain freshwater molluscs belonging to the genera *Sphærium* and *Pisidium*. Morphologically this carapax is but the greatly expanded dorsal portion of the mandibular or a post-mandibular segment, and forms a good illustration of the hypertrophy of parts to which we have alluded on page 7. The two pairs of antennæ are present, but in some of the Apodidæ the first pair is small and the second is occasionally absent. The mouth-parts are a pair of mandibles, two pairs of maxillæ, and in *Apus* and its allies a pair of maxillipeds. The locomotive feet are foliaceous and membranous, giving the name to the order, and as portions of them (the exopodites) have respiratory functions, the name Branchiopoda (gill-footed) is also appropriate. The feet vary largely in number, there being fourteen in *Limnetis* and sixty in some species of *Apus*. There is no distinction to be drawn between the thorax and abdomen, while the number of segments in these portions shows nearly the same variability as is exhibited by the locomotive members, there being twelve in *Limnetis* and twenty-seven in *Estheria* and forty-two in *Apus*. The abdomen terminates in a telson, which bears a pair of appendages in all the genera except *Thamnocephalus*.

The internal anatomy, as a whole, follows the usual crustacean type, and only the modifications peculiar to the order need be mentioned. The heart, which occupies the usual position, is a more or less elongated tube, partially divided into a series of chambers by annular constrictions. The alimentary canal is a simple tube, sometimes lined with glandular bodies of uncertain function. The liver is large, and, contrary to the usual rule in Crustacea, is placed in the anterior portion of the body, in front of the œsophagus and beginning of the stomach. The brain or supra-œsophageal ganglion is very small, and is connected with the ventral chain in the usual manner. Of this ventral nervous cord nothing need be said, but the brain possesses a peculiar interest. In the higher Crustacea, so far as our knowledge goes, the brain is composed of two or more ganglia fused together, and from it arise the nerves supplying the eyes, and both pairs of antennæ, but in the Phyllopoda the brain consists of but a single ganglion, and the nerves which arise from it supply only the optic organs.

Attractive as they are in form, habit, and structure, the Phyllopoda possess a higher interest when we study their development and the many curious features connected therewith. The young Phyllopoda leave the egg in the nauplius stage, which, however, presents several differences from the larvæ of other Crustacea to which the

same name is applied. In some the first pair of appendages are absent, in others they are well developed. Some have the segments of the body behind the mandibles well indicated, while in others no indication of segmentation is visible. From this point the development is more or less direct, no startling metamorphosis being introduced. With succeeding moults new segments are introduced, and new limbs appear, until the adult condition is reached. In the Limniadiadæ at an early age the carapax of the nauplius becomes folded so as to form the bivalve shell of the adult. It is uncertain whether all of this shell is moulted, but the evidence adduced seems to us to indicate that at least in *Estheria* it is not wholly cast, and that the concentric lines upon the outside are in reality lines of growth, like those so familiar among the Mollusca.

An interesting feature of the eggs of the Phyllopods is their ability to withstand dessication; in fact, the only species so far as known whose ova have not this power is *Lepidurus productus* of Europe. This power is not, however, confined to this group, but is possessed by *Cypris*, *Cypridinæ*, *Daphnia*, and many Copepoda. It is apparently a necessary provision for the perpetuation of these



FIG. 48. — Nauplii of (a) *Artemia salina* and (b) *Apus cancriformis*.

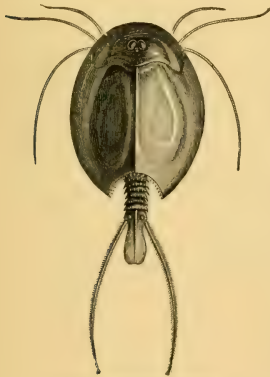


FIG. 49. — *Lepidurus productus*.

forms, for the puddles in which they dwell usually become dry in the summer, and were it not for this peculiarity of the eggs the species would soon disappear. When the mud is wet again by the spring thaw the eggs hatch, but it is not necessarily the ova deposited by last year's brood which people the puddle, for Dr. Semper found that mud which was taken from a pond in which he had found *Apus* gave no young the first year, and but few the second; but in succeeding years he was able to hatch out nauplii in great numbers. In 1872 Professor Zittel collected mud in the oasis of Dahel, which was sent to Professor von Siebold, and produced nauplii of *Artemia* in 1877, but none in previous years. A still further peculiarity is the fact that, at least in several species, it is necessary that the mud containing the ova should become dry in order that the eggs may hatch. So far as known a single species of *Chirocephalus* is the only form in which

this dessication is not an absolute essential; and further, the researches of Professor Brauer show that the eggs of several Phyllopoda develop most rapidly, and, perhaps, only, when they have previously been exposed to a temperature near the freezing point. The length of time required for hatching and development varies here, as in other groups, with the temperature. *Branchipus* and *Apus* eggs require several weeks at

a temperature of 60° to 65°, but at 85° the nauplii appear in less than twenty-four hours. This power of withstanding the effects of dessication has enabled naturalists to

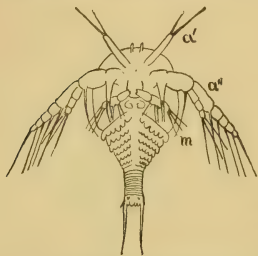


FIG. 50.—Nauplius of *Apus lucasanus*. α' , Antennule. α'' , Antennæ. *m*, Mandible.

ADIADÆ, has the body enclosed in a bivalve shell, the antennule small, the antennæ large and well developed; from ten to twenty-seven pairs of swimming feet. In the male one or two of the first pairs of feet are provided with a pincer, while in the females they are simple. The telson is large, and bears a pair of appendages. The genera are four in number, *Limnetis*, *Estheria*, and *Limnadia* being the most prominent. Compared with the other families the Limnadiadæ possess but few points of popular interest.

The family APODIDÆ contains but two genera, *Apus* and *Lepidurus*. In these the anterior portion of the body is flattened, and covered with a broad and somewhat ovate carapax, from beneath which the abdominal segments project behind, giving the animal, at the first glance, a somewhat striking resemblance to the horse-shoe or king-crab, *Limulus*, with which, indeed, they were originally classed by Otto F. Müller. As in the preceding family, the compound eyes are sessile. The antennæ are small, the second pair sometimes being absent; the post-oral appendages usually number sixty-three pairs, some of the segments bearing as many as six pairs apiece. The eleventh pair are modified to form the egg-sacs in the female. The terminal segment of the body bears two long-jointed appendages, and terminates either abruptly (*Apus*) or in a long paddle-like outgrowth (*Lepidurus*). The family has its best representation on our western plains and in the Rocky Mountains, where six species occur, while from all the rest of the world less than twenty species are known. In America, outside these limits, but three forms are known,—one in Greenland, one in

study the habits and development of these interesting Crustacea in places far from their original habitat. Thus Professor Claus, in Vienna, found it easy to investigate the anatomy of *Daphnia atkinsoni*, from Jerusalem; Professor Siebold, at Munich, was enabled to study the habits of *Artemia gracilis*, hatched from mud brought from Great Salt Lake; and Dr. Gissler, in Brooklyn, studied the embryology of *Apus lucasanus*, from eggs obtained in the same manner from Kansas. The figure we give of the nauplius of *Apus* was drawn by Dr. Gissler from one of these specimens.

There are three well-marked families of Phyllopoda, all of which are represented in North America. The first family, LIMN-



FIG. 51.—*Apus equalis*, natural size.

the West Indies, and the third in Lower California. None are known in the United States east of the Mississippi River. The Apodidae frequent shallow pools, where they sometimes occur in countless myriads, swimming, like the members of the next family, upon their backs, with a graceful motion, or burrowing in the soft ooze of the bottoms of the puddles, somewhat like a *Limulus*, in search of food, which, so far as is known, is of an animal nature.

The most interesting feature in connection with *Apus* is its parthenogenetic reproduction, which also occurs in *Lepidurus*, *Limnadia*, and *Artemia* among the Phyllopoda, as well as elsewhere in the Arthropoda. In plain English, parthenogenesis means a reproduction by means of unfertilized eggs, the influence of the male element being unnecessary. The investigations of this interesting subject are mainly the work of Professor Siebold, of Munich. He was led to study by the fact that at that time (1856) no males of *Apus cancriformis* were known. In 1858 males were discovered, "and Siebold received specimens from various localities: He thus learned to distinguish with perfect facility the two sexes, and was able to convince himself that with *Apus* broods occur which are entirely destitute of males, and go on reproducing parthenogenetically, while other broods occur in which both sexes are present." "On one occasion, he had the whole contents of a little pond removed with the greatest care, so as to feel sure that he had obtained every *Apus* present. He obtained on this occasion 5,796 specimens of *Apus*, every one of which, being carefully examined, proved to be a female." Afterward he experimented with *Artemia*, using every care to exclude males and spermatozoa, and demonstrated beyond a question that virgin females will deposit eggs from which, unfertilized by any male sperm, a brood can develop. How far either *Apus* or *Artemia* can continue reproducing parthenogenetically has not yet been determined.

The BRANCHIPODIDÆ, the highest family of the order, lacks the carapax, so characteristic of the other two, though the homologues of the shell glands persist in a rudi-



FIG. 52. — Dorsal and side views of *Lepidurus conzei*, natural size.

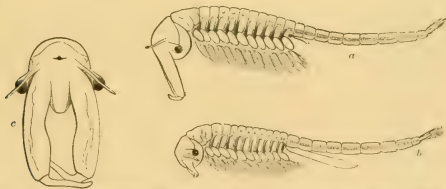


FIG. 53. — *Branchinecta coloradensis*. a. Male. b. Female. c. Front of head of male, showing claspers.

mentary condition in the adults of at least some species. The head is small, and the compound eyes are placed upon a stalk similar to that in the Podophtalmia (to be discussed further on), while the median ocellus (the eye of the nauplius) persists in

the adult. Both pairs of antennæ occur, the second being modified in the males to produce clasping organs. The locomotive feet are eleven in number, the only exception being nineteen in the Siberian genus, *Polyartemia*. The distinction between the cephalo-thorax and abdomen is better marked than in the other families, and the abdomen bears two simple unjointed appendages. In many forms the front of the head is prolonged into a peculiar appendage, which varies much in shape in the different species.

The genus *Branchipus* is, in the eastern parts of the United States, the most common of the Phyllopods, and the species known as *B. vernalis* is one of the most familiar fresh-water forms. Like others of the Phyllopoda, it inhabits temporary pools, those formed by the melting snow in the early spring being favorite localities. Here they may be found swimming on their backs in the most graceful manner imaginable, their beautiful shades of red, flesh color, white, and greenish adding not a little to their beauty. It is just these features which render it impossible for one to make any drawing or illustration which will in any way compare with the originals.

Artemia is a salt-water, or rather brine inhabiting, form, illustrated in North America, according to the latest authority, by but a single species, *Artemia gracilis*. This is found in immense numbers in Great Salt Lake and Mono Lake, and in brine pools elsewhere in the country. They are frequently found in the salt water which is kept in tubs on the railroad bridges across the heads of bays and similar places along the sea-coast. The food is apparently vegetable.



FIG. 54.—a. *Branchinecta grubei*, male. b. Female, natural size. c. *Artemia salina*, enlarged.

In technical characters this and the next genus differ as follows: *Artemia* has eight abdominal segments without appendages; the second antennal claspers of the male have their second joint flat and triangular, while the ovisac is short. In *Branchinecta* the abdomen has nine segments, the male claspers are simple and cylindrical, and the ovisac is long and slender. Under ordinary circumstances these would be considered as of generic value, but what shall we say when we know the results of the observations and experiments of the Russian naturalist, Vladimir Schmankevitsh? Condensed from his account these were as follows: In 1871 the spring flood broke down the barriers separating the two different lakes of the salt-works near Odessa, diluting the water in the lower portion to 8° Beaumé, and also introducing into it a large number of the brine shrimp, *Artemia salina*. After the restoration of the embankment the water rapidly increased in density, until in September, 1874, it reached 25° of Beaumé's scale, and began to deposit salt. With this increase in density a gradual change was noticed in the characters of the *Artemia*, until, late in the summer of 1874, forms were produced which had all the characters of a supposed distinct species, *A. muehlhauseni*. The reverse experiment was then tried. A small quantity of the water was gradually diluted, and, though conducted for only a few weeks, a change in the direction of *A. salina* was very apparent. Led by these experiments he tried still others:

Taking *Artemia salina*, which lives in brine of moderate strength, he gradually diluted the water, and obtained as a result a form which is known

as *Branchinecta schafferi*, the last segment of the abdomen having become divided into two. Nor is this change produced by artificial means alone. The salt pools near Odessa, after a number of years of continued washing, became converted into fresh-water pools, and with the gradual change in character *Artemia salina* produces first a species known as *Branchinecta spinosus*, and at a still lower density *Branchinecta ferox*, and another species described as *B. medius*. We have already referred to parthenogenesis in this genus.

There are only two other genera of this family which need to be mentioned, *Chirocephalus* and *Thamnocephalus*. In these genera the frontal process, which is small in *Branchipus*, acquires a great development, branching in the latter genus, which is peculiar to America, in a manner recalling the limbs of a tree, whence the scientific name of the genus, — bushy head. *Thamnocephalus* also differs from all the other genera of Phyllopoda in the absence of appendages to the telson.

Several species of Phyllopoda are known in a fossil condition, four being found in American strata. *Estheria* occurs in the Devonian of Europe, while *Leaia*, a more or less problematical form, occurs in the lower carboniferous of both Great Britain and Pennsylvania. *Apus* first appears in the Triassic, while *Branchipus* dates back to the Eocene.

J. S. KINGSLEY.

SUB-CLASS III.—PODOPHTHALMIA.

This division receives its name from the fact that the eyes are situated upon movable peduncles; and while this feature of itself is of slight importance, and, moreover, is not found in all members of the group, and, on the other hand, exists among the Tanaisida, which have a doubtful position among the Isopoda, and the Phyllopoda, still the character is so nearly universal that we may be permitted to employ the name for the group. The name Decapoda, which we have employed to designate a single order, is frequently used as synonymical with Podophthalmia, but it is even more inappropriate than that term for the whole group.

The general characters of the order are a body of twenty segments, as in the Edriophthalmia, a carapax which extends over some, if not all, of the thoracic somites; the two pairs of antennæ are always present, the eyes (except in Cumacea and one or two aberrant forms) are well developed, and placed on jointed peduncles. Respiration is effected by well-developed gills, and in their development the Podophthalmia usually pass through a more or less complicated metamorphosis, in which, in contradistinction to the lower sub-classes, a nauplius stage is rare.

Though this sub-class has been the subject of more study than any other group of Crustacea, its classification is as yet in a very unsatisfactory condition. For our present purposes the following grouping, which fairly represents our knowledge of the subject, may answer: Order I., Phyllocarida; Order II., Schizopoda; Order III., Decapoda; Order IV., Stomatopoda; Order V., Cumacea.

ORDER I.—PHYLLOCARIDA.

This group, which is represented on the eastern coast of North America by two species of *Nebalia*, a northern *N. bipes* and an as yet undescribed species from Florida, is of very uncertain position, some classing it with the Phyllopoda, others with the Podophthalmia, while Dr. Packard prefers to consider it as distinct from both. With this uncertainty it may be well to allow it for the present to remain near *Mysis*, to which it is evidently closely allied. *Nebalia* has a compressed body. The rostrum is articulated to the carapax. The second pair of antennæ are nearly as long as the body. Three pairs of mouth-parts are present, and following them are eight pairs of short leaf-like feet with respiratory functions. Next come four large and two small pairs of abdominal feet (the latter inadvertently omitted in the cut). The last abdominal segment terminates in two large spines.

As has been said, the development closely resembles that of *Mysis*, and the animal hatches with all of its appendages outlined, although there exists a time, while the embryo is within the egg, when the features of the nauplius are hinted at, followed by another which recalls the zoea of the Decapoda. Doubtless Dr. Packard is correct in following Salter and Huxley in regarding the fossil forms which occur in the strata



FIG. 55. — *Nebalia bipes*, enlarged; one-half of the carapax removed.

from the Lower Silurian to the Carboniferous, as representing on a grand scale (*Dithyrocaris* being over a foot in length) the *Nebalia*, half an inch in length, of the present day.

ORDER II. — SCHIZOPODA.

The name of this order means cleft feet, and was given in allusion to the biramous or two-branched character of the thoracic appendages of the adult, both exopodite and endopodite being present and well developed. This schizopodal character of the appendages, which remains as a permanent feature in this group, is found only as a transitory feature among the larvæ of most of the Decapoda, thus clearly showing the higher position of the latter order. The number of pairs of these functionally thoracic

feet varies from six in *Mysis* to eight in *Thysanopoda*, the increase in number over that to be noticed in the Decapoda being produced by the transfer of mouth-parts to the locomotive series. The abdomen is relatively very large, being frequently more than twice the length of the cephalothorax. Gills, when present, are attached to the



FIG. 56. — *Mysis stenolepis*, opossum shrimp, enlarged.

thoracic feet, but instead of being enclosed in a gill-chamber hang freely in the water. In a few forms it has been observed that the posterior extremity of the digestive tract plays a part in respiration, it being richly supplied with blood-vessels, while water is drawn into and then forced out from the anus. It may be interesting in this connection to note that a somewhat similar feature exists in some fishes. *Cobitis fossilis* and several Brazilian forms swallow small bubbles of air, which, in passing through the intestine, aerate the blood, while similar habits among the Invertebrata, — insects, worms, and holothurians, are numerous. Several species of *Mysis* and allied genera are common on our eastern coasts, forming a prominent portion of the food of many of our shore fishes. We figure *Mysis stenolepis*.

In their development two types are exhibited by the Schizopoda, that furnished by *Mysis* and that observed in *Euphausia*. *Euphausia* leaves the egg as a true nauplius with its three pairs of appendages, a mouth being present, though the alimentary tract is not open at the posterior end. With the succeeding moults new appendages are formed and the carapax outlined, while the abdomen does not make its appearance, except in a very rudimentary condition, until six appendages are outlined. A modified zoeal condition now ensues, from which the adult condition is gradually produced by a series of successive moults. In *Mysis* the eggs and young are carried in an incubatory

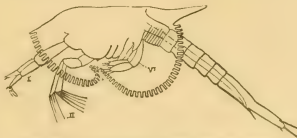


FIG. 57. — Later nauplius of *Euphausia*, enlarged.
i, ii, vi. Appendages.

pouch beneath the thorax, from which the common name of these forms, "opossum shrimps," is derived. The floor of the pouch is formed from plates arising from the bases of the legs in a manner similar to that found in the Edriophthalmia. When the nauplius stage of the young is reached, the egg of *Mysis* hatches, but as a free life does not begin until much later, the nauplius skin is not at once thrown off, and the subsequent changes are effected within it.

ORDER III. — DECAPODA.

This group embraces the largest, most interesting, and most useful forms of Crustacea, and although the general structure is the same, the variation of the different parts in size and proportion is such as to produce a great diversity in appearance. At first sight the contrast between the shrimps, whose length is frequently ten times their breadth, and *Lea*, three times as broad as long, renders it difficult to realize that the two are in any way related, though in reality every homology can be traced between the two. Almost every part is essentially the same in each, the difference being only in the "mode of expression," to use a term which belongs to the science of forty years ago.

The Decapoda, like all of the Podophthalmia, have twenty segments of the body, each, with the exception of the hinder one, bearing at some period of life a pair of appendages. Of these, the two anterior (antennulæ and antennæ) are especially devoted to the senses; next come six pairs which play a part in eating, followed by five pairs of feet (ten in all), which are of use in locomotion. On the abdomen are six pairs of small feet in the lower forms, while in the higher groups, in the males, these are mostly aborted, and in the females are used only as supports for the eggs. As was stated on a previous page, the terms head, thorax, and abdomen, when used in reference to the Crustacea, imply functional and not morphological regions of the body; and so, in treating of the Decapoda, the cephalic appendages extend from the antennulæ to the external maxilliped; the thoracic members are the five large pairs used in locomotion, while the abdominal legs embrace those on the seven last segments of the body.

Going more into details, we will now discuss the various modifications of these appendages and their functions. The anterior pair, the antennulæ, are always small, and bear the ear on the basal joint. In some cases these antennulæ terminate in a single flagellum, while in others they are two, or even three-branched. The antennæ usually are much larger, and in the higher forms are unbranched, the exopodite disappearing with development. In the lower forms it, however, remains as a scale or inconspicuous spine. On the basal joint is the external opening of the "green gland," an organ supposed to be renal or depuratory in function. Both the antennæ and antennulæ are fringed with hairs, and are the special seat of feeling, and possibly of smell as well. Of the mouth-parts the most anterior are the mandibles, a pair of powerful organs which play a part in the comminution of food, preparing it for entrance into the mouth, which lies between them. The mandibles usually bear a jointed continuation, the palpus, which in life assists in cleaning the cutting surfaces,—a crustacean tooth-brush, it might be called. Two pairs of delicate, leaf-like maxillæ come next, the first being without exopodite, while the second has this branch greatly developed, forming the scaphognathite or gill bailer, to which reference was made on a preceding page. In life this appendage is kept in constant motion, pumping water over the gills. The next three pairs, maxillipeds by name, have the exopodite well developed.

The thoracic feet in some of the lower groups retain, even when adult, the exopodite, though in a very rudimentary condition. In the higher forms it always entirely disappears. One or more of these thoracic feet usually terminate in a pincer or chela, which can be used in grasping or crushing. In the lobster these pincers acquire a great development, and no mention is necessary of the strength with which they can pinch. At first sight it would appear as if, in order to form the pincer, the end of the leg was split, but a little examination shows that in reality the chela is produced by the last joint of the leg meeting a prolonged portion of the preceding joint, and in some forms (*e. g.* *Crangon*) intermediate stages can be seen where this inner angle is not produced so far, and the terminal joint has to bend at right angles in order to meet the palm.

Among the abdominal feet the amount of variation is but slight, and when present, all, except the first pair, which are modified for reproductive purposes, are biramous; the last pair in the *Macrura* uniting with the last segment of the body, the telson, to form the powerful caudal fin which the animal uses in swimming backward through the water. As will be seen when we come to the subdivisions of the Decapoda, the abdomen shows a good deal of variation in size and development, which need not here be discussed.

We have already referred to the position of the mouth, which is situated between the mandibles. In front we have a fleshy upper-lip, and below an under-lip, which in every way, both in structure and development, appears to be an appendage homologous with the others, but which, until the present decade, has never been so considered. Respiration is effected (with a very few exceptions) by gills, which are always present, and are attached to the basal joints of the thoracic limbs and a few of the mouth-parts, and extend up into the gill-chamber already described. The heart is a strong, small, and compact organ, situated in the middle of the upper part of the thorax. From it arise five arteries; one supplying the eyes, one the upper surface of the abdomen, one goes down to the lower surface of the body, and there dividing, supplies the appendages, while the two remaining arteries, one on each side, convey the blood from the heart to the viscera.

The eggs of the Decapods, after exclusion from the genital organs, pass back, and are attached to the abdominal feet of the mother, where they undergo a portion of their development. The eggs of the Decapods have a regular segmentation, but, owing to the fact that the protoplasm has a peripheral distribution, the planes of cleavage do not pass completely through the egg. When the segmentation is completed, a small patch of the blastoderm invaginates to form the primitive stomach, and the opening or blastopore soon closes. By similar invaginations the anterior and posterior portions of the digestive tract are formed, each pushing in until it meets the first invagination. Anticipating for a moment our account, we will say that here, as in all Crustacea, the primitive stomach, or mesenteron of embryologists, forms but a very small portion of the alimentary tract, and that from the anterior invagination, the stomodæum, as it is called, the stomach with its complicated mill is developed. Hence it is that when the animal casts its skin, the lining of the stomach is also shed. Returning now to our egg, the next feature seen is a small prominence, the future abdomen, and then the first three pairs of appendages appear nearly simultaneously, giving rise to the nauplius stage. *Lucifer* (which presents an exception to the other Crustacea, in having a total segmentation and in the formation of a true segmentation cavity) and *Pennæus* leave the egg at this point, and we will follow their further development at another

place. All other Decapods remain awhile longer in the egg, and usually a free life begins with a zoeal condition, which, however, is subject to various modifications, which will be mentioned in their proper place.

So far as the writer is aware, all Decapods follow two modes of casting the shell. In the *Macrura* the carapax splits longitudinally down the back, and the body is withdrawn through the opening thus produced. In the *Brachyura*, on the other hand, the splitting of the shell, though still dorsal, is transverse, and takes place between the last segment of the thorax and the first of the abdominal series. As a preparation for casting the shell Dr. Braun describes in the crayfish a series of hairs, developed at about the time of moulting, on the surface of the hypodermis, which serve to lift up the old and hardened integument. Before the time of moulting there is developed on either side of the stomach an oval mass of carbonate of lime, which is usually regarded as a supply stored up for the calcification of the new integument. From the fact that in the crayfish these "crab-stones" weigh but about two grains, Professor Huxley is disposed to question this explanation, that small amount being but slight in proportion to the animal. In the lobster, and in other forms, these stones are much larger, and there the objection of insufficiency would hardly apply.

Connected with the moulting is the reparation of injuries. When a crustacean loses a leg, or suffers an injury in any part, with the succeeding moults the damages are repaired, but not always perfectly. Some interesting observations on this point have recently been made by Dr. Faxon, especially on the claws of the lobster. Frequently when the claw is injured, instead of acquiring its former shape, there is a tendency toward the formation of another pincer; the two jaws are formed, their inner margins become armed with teeth, but the apparatus cannot answer for a pincer, for the joint allowing it to be closed is never formed, and the two parts are never able to come together. This tendency of nature to reproduce parts forms a very interesting subject for investigation, for which, aside from a meaningless jingle of words, no explanation has yet been given.

Many Crustacea have the power of producing a noise, but whether these sounds are employed as calls, the evidence as yet presented, does not enable us to decide. In many forms, as *Gelasimus*, *Ocypoda*, and *Palinurus*, these sounds are produced by rubbing together two parts of the hardened integument, and frequently stridulating organs for this purpose are well developed. A description of that in *Ocypoda* will suffice. In all the species of this genus there occurs in the inside of one of the large pincers a row of closely set granules, which can be rubbed across a corresponding ridge on the carapax, producing a noise closely resembling that which results from rubbing some hard substance over a coarse file. In many species of the genus *Alpheus*, the movable finger of the large claw is armed with a strong tooth, which fits into a corresponding socket in the immovable thumb. By opening the claw and drawing the tooth from the socket these small Crustacea are able to produce a noise similar to that produced by snapping the finger-nails together.

It has been stated several times in the preceding pages that the Crustacea are essentially an aquatic group, but there are some which always live on land, only repairing to the water for the purposes of reproduction. So far have these forms become accustomed to a terrestrial life and an atmospheric respiration, that Fritz Müller has proved by actual experiment that it is possible to drown a sand crab (*Ocypoda*) by a prolonged immersion in water, and we can do no better than to reproduce here some of his remarks upon the respiration of other terrestrial Decapoda, quoting from the

excellent translation by Mr. Dallas of "Für Darwin," and using to a large extent the exact words, though that fact is not indicated by quotation marks.

Among the numerous facts in the natural history of Crustacea, there is one which appears of particular importance, namely, the character of the branchial cavity in the air-breathing crabs. In the frog-crab (*Ranina*) of the Indian Ocean, which, according to Rumphius, loves to climb up on the roofs of the houses, the anterior entrant orifice to the branchial cavity is entirely wanting, according to Milne Edwards, and the entrance of a canal, opening into the hindmost parts of the branchial cavity, is situated beneath the commencement of the abdomen. The case is most simple in some of the Grapsoidea, as in *Aratus pisonii*, a charming, lively crab, which ascends the mangrove bushes and gnaws their leaves. By means of its short but remarkably acute claws, which prick like pins when it runs over the hand, this crab climbs with the greatest agility upon the thinnest twigs. Once, when one of these animals was sitting on my hand, I noticed that it elevated the hinder portion of its carapax, and that, by this means, a wide fissure was opened upon each side, above the last pair of feet, through which I could look far into the branchial cavity. I have frequently repeated the same observation upon another animal of the same family (apparently a true *Grapsus*), which lives abundantly upon the rocks of our coast [Southern Brazil]. Whilst the hinder part of the carapax rises, and the above-mentioned fissure is formed, the anterior part seems to sink, and to narrow or entirely close the anterior entrant orifice. Under water the elevation of the carapax never takes place. The animal, therefore, opens its branchial cavity in front or behind, accordingly as it has to breathe water or air.

I have also observed the same elevation of the carapax in some species of the allied genera, *Sesarma* and *Cyclograpsus*, which dig deep holes in marshy ground, and often run about in the wet mud, or sit, as if keeping watch, before their burrows. One must, however, wait for a long time with these animals, when taken out of the water, before they open their branchial cavity to the air, for they possess a wonderful arrangement, by means of which they can continue to breathe water for some time when taken from that element. The orifices for the egress of the water which has served for respiration are situated in these, as in most crabs, in the anterior angle of the buccal frame, while the entrant fissures of the branchial cavity extend from its hinder angles above the first pair of feet. Now, that portion of the carapax which extends at the sides of the mouth between the two orifices appears in our animals to be divided into small, square compartments. This appearance is caused partly by small wart-like elevations, and partly and especially by curious geniculated hairs, which, to a certain extent, constitute a fine net or hair-sieve extended immediately over the surface of the carapax. Thus, when a wave of water escapes from the branchial cavity, it immediately becomes diffused in this network, and then is again conveyed back to the branchial cavity by vigorous movements of the appendage of the outer maxilliped, which works in the entrant fissure. While the water glides in this way over the carapax, in the form of a thin film, it will again saturate itself with oxygen, and may then serve afresh for the purposes of respiration. In very moist air the store of water contained in the branchial cavity may hold out for hours, and it is only when this is used up that the animal elevates its carapax in order to allow the air to have access to its branchiæ from behind.

In the Sand Crabs (*Ocypoda*) a peculiar arrangement on the third and fourth pairs of feet has long been known, although its connection with the branchial cavity has not

been suspected. These two pairs of feet are closer together than the rest, and the adjoining surfaces of their basal joints are smooth and polished, and their margins bear a dense border of long, silky, and peculiarly formed hairs. Milne Edwards, who compares these surfaces as to appearance with articular surfaces, thinks that they serve to diminish the friction between the two feet. In considering this interpretation the question could not but arise, why such an arrangement for the diminution of friction should be necessary in these particular crabs, and between these two feet, leaving out of consideration the fact that the remarkable brushes of hair, which, on the other hand, must increase friction also remain unexplained. But, upon bending the feet of a large sand crab to and fro in various directions, in order to see in what movements of the animal friction occurred, at the place indicated it was noticed, when the feet were stretched widely apart, there was in the hollow between them a round orifice of considerable size, through which air could be blown into the branchial cavity, and a small rod might even be introduced. While in *Grapsus* the water reaches the branchiæ only in front, in *Ocypoda* it flows in through this orifice. A somewhat similar structure is found in two species of fiddler crabs, and our author is disposed to regard the hairs mentioned as possibly organs of smell.

It may not be amiss to state in this connection the reasons why most gill-bearing animals die when taken from the water. Although the amount of oxygen present in the air greatly exceeds that in water, the gills, usually soft in character, so mat together when the supporting influence of the water is withdrawn, that the extent of surface available for respiration is not sufficient for the needs of the animal, and hence suffocation ensues.

The Decapoda are usually divided into Macrura or long-tailed crabs, Brachyura or short-tailed crabs, and a third group, Anomura, standing between the two first mentioned, and to a certain extent combining the characters of each. When, however, we come to study the embryology it is seen that the members of the Anomura should be divided among the two groups first mentioned; and further, that the usually adopted arrangement of the divisions of the Brachyura does not represent their true relationships. So, following the hints afforded us by the development, which, when properly interpreted, are in full accord with those furnished by comparative anatomy, we will divide the Decapoda into two sub-orders, Macrura and Brachyura, each in turn containing several distinct sub-divisions.

SUB-ORDER I. — MACRURA.

The Macrura, embracing the shrimps, prawns, lobsters, crayfish, and hermit crabs, are characterized by the possession of an elongate body, the abdomen being very large and not habitually folded under the thorax. The carapax is frequently long and cylindrical. Both pairs of antennæ are long and filiform; the inner pair are never folded away in little pits, as in the Brachyura; the outer pair frequently bear a lamellar appendage at the base, the modified exopodite. The buccal area is not margined in front, while the external maxillipeds are strongly pediform. Attached to the abdomen are usually six pairs of appendages, the sixth pair uniting with the last segment of the body to form the powerful caudal fin, so useful to these animals in locomotion. With the exceptions of the Penæidea and Astacidea, whose development will be mentioned further on, the Macrura hatch from the eggs as zoeas, in which the first eight appendages (ending with the external maxillipeds) are present, while all of the thoracic

and abdominal feet are usually absent. These zoeas differ from those of the Brachyura in that the enormous defensive spines, so characteristic of the larvae of that sub-order, are here but very slightly developed, thus enabling one at the first glance to say to which group any larva belongs. From the zoea a *Mysis*-like stage is produced, in which the thoracic and finally the abdominal feet appear, the thoracic feet exhibiting as a temporary character the schizopodal form, which is retained in the adult opossum-shrimp. From this the change to the adult condition is gradual. To this one exception may be noted; in the hermit crabs (Paguridea) and Thalassinidea, so far as known, the *Mysis* stage has disappeared.

For our purposes we may divide the Macrura into the groups Penaeidea, Caridea, Astacidea, Thalassinidae, Galatheaidea, and Paguridea, the two latter embracing a portion of the old group Anomura, each in turn being divisible into several families.

The PENÆIDEA, with its two families PENÆIDÆ and SERGESTIDÆ, though a well-marked group, is not easily defined in words, if we rely upon characters derived wholly from the adult, but the three genera, whose development has been studied, *Lucifer*, *Sergestes*, and *Penæus*, all leave the egg in the nauplius condition, and are thus in strong contrast to all the other Decapods. Aside from their development, — a slight account of which will be given, — the whole group possesses but few points of interest. Of *Lucifer*, a small transparent form, one species of which is found on our southern coast, we have, thanks to that able naturalist, Dr. Brooks, one of the most complete



FIG. 58. — Nauplius of *Lucifer*.

life-histories yet published. The eggs, contrary to those of most Crustacea, are almost entirely composed of protoplasm, and undergo a total segmentation, followed by the formation of a true segmentation cavity. From the egg there hatches a true nauplius, which, by two moults, produces a protozoea with an elongate but unsegmented abdomen, and a well-developed carapax. Seven pairs of appendages are now present, while the segments of the body corresponding to the third maxilliped and the three first thoracic limbs are outlined. The heart is formed, and Dr. Brooks thinks that water was drawn in and expelled from the posterior portion of the intestine, a feature which would remind us of the intestinal respiration already mentioned in connection with *Mysis* on a preceding page. With three moults, during which nearly all of the thoracic and abdominal segments appear, while the compound eyes are developed (in a manner which, if we rightly interpret the text and drawings of Dr. Brooks, lends not the slightest countenance to the idea that they are homologically jointed appendages), the zoea is reached. From this point the development is much more gradual, the larva passing through a *Mysis* stage, and reaching essentially the adult form when about half an inch long.

The development of *Penæus*, so far as known, corresponds in a general way with that of *Lucifer*, while in *Sergestes* some of the larval stages are characterized by very peculiar branching spines.

The species of *Penæus*, all of which have the three anterior pairs of feet chelate, are very numerous in the warmer seas of the globe, and form an important article of food. In the Southern States large numbers of *Penæus braziliensis* are sold under the name of shrimp.

The only other form of Penæoid which needs mention is the curious *Spongicola*



FIG. 59. — *Lucifer* (natural size, $\frac{2}{3}$ of an inch in length).

which is frequently found in that beautiful sponge from the Philippines (*Euplectella*), which has received the name of "Venus' flower-basket." It was formerly supposed that these small shrimps were inserted in the sponge, and the opening then skilfully closed by those ingenious people of the East to whom we owe so many "curios," from mermaids to curious carved balls of ivory, one within the other. Such, however, is not the case. Not only has no one yet been able to discover the openings which would be necessary for such an operation, but every specimen thus imprisoned belongs to the same species, — a fact which would hardly be probable were we indebted to man for the arrangement.

The next group in order is the CARIDEA, which is represented in all seas by many species, some also occurring in fresh water. In North America alone, including the West Indies, about one hundred distinct forms occur. In these forms the antennæ have a large basal scale, the carapax is not joined at its inferior margin to the mandibular and antennal segments, while at the most only the two anterior pairs of thoracic feet terminate in a pincer, while frequently but a single pair (either the first or second) has such a termination. In *Nika* an interesting modification takes place, — only one foot of the anterior pair is chelate, the other being monodactylous. Another feature, which is common to many genera, is the breaking up of the carpal (antipenultimate) joint of one pair of legs into a long series of annuli, affording great freedom of motion, though the pincers borne on these feet are always so small as to render it difficult to see what can be the gain to the animal by this structure.

In the eastern United States the Caridea are of but slight economic importance, but in other parts of the world, under the names of shrimps and prawns (German *Garneelen*, French *crevette*), they are largely used as an article of food. The shrimp of England is the *Crangon vulgaris* of science, while the term prawn

is applied indiscriminately to species of *Palaemon*, *Pandalus*, and *Hippolyte*. *Crangon vulgaris* is common to the shores of Europe and both coasts of North America. In color it is a dirty white, finely speckled with black, presenting a close resemblance to the sandy shores on which it dwells, and thus affording a certain protection, for almost every shore fish is fond of the delicate crustacean. In England and on the adjacent shores of the continent a common way of catching shrimps is by "horse-power,"—a horse dragging behind him a large net is made to walk up and down through the shallow water, and the Crustacea are held in the meshes. Shrimps are prepared for the table by boiling. In California the shrimp fisheries are almost entirely in the hands of the Chinese, and the following account taken from the Bulletin of

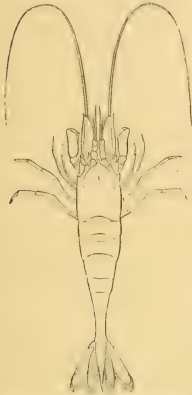


FIG. 60. — *Crangon vulgaris*, natural size.



FIG. 61. — *Pandalus montagu*, slightly reduced.

the Fish Commission tells their method of preparation :—

"That part of each day's catch which is not sold is carried to the Chinese quarter, and there put at once into boiling brine. The shrimps are then spread out to dry upon level plats of smooth, bare ground. After four or five days they are crushed under large wooden pestles, or trod upon by the Chinese in wooden shoes, for the purpose of loosening the meats from the outer chitinous covering; after which the entire mixture is put through a fanning mill, for the actual separation of the meats from the shells. About 200,000 pounds of shrimps are sold annually in San Francisco, and the annual exports of shrimp-meats to China and the Sandwich Islands are valued at about \$100,000. The meats are eaten by all classes in China, but they are cheaper and less esteemed than the native shrimps, which are said to be comparatively scarce."

Of the habits and details of structure of the Caridea but little of general interest can be said. The families are founded upon the character of the mandibles, while the maxillipeds and thoracic feet afford a means of division into genera. The genus *Palaemon* contains a large number of species, and occurs both in salt and in fresh water, one form (*Palaemon chionis*), as its name indicates, being found in the Ohio and Mississippi Rivers. Some of the East Indian species acquire a great size,—*Palaemon carcinus*, from the tip of the chelipeds to the end of the telson, sometimes measuring nearly two feet, while our own *Palaemon jamaicensis* is nearly as large. The genus *Alpheus*, with about sixty species distributed over the warmer seas of the world, usually leads a burrowing life, some of the Floridan species living in sponges. In these forms the carapax has grown forward so as to completely cover the eyes, while the anterior pair of feet present an interesting peculiarity. These feet are both ter-

minated with pincers, one being small while the other is enormously developed, being as large as the cephalothorax. This genus is almost exclusively marine, but some species are occasionally found in fresh water as well. In one of these from Florida (*Alpheus minus*) the marine forms are very small, while specimens obtained from fresh water, belonging to the same species, were nearly three times as large.

None of the Caridea are true parasites, though a few are commensals, that is, they are closely associated with other animals. Thus some species of *Alpheus* and *Pontonia* live within the shells of certain molluscs.

The ASTACOIDEA is a much more important group than the one that we have just left, embracing as it does many large species possessing an alimentary interest. Without entering into the characters limiting this group, we may proceed to divide it into three families, — Astacidae, Loricata, and Thalassinidae.

The ASTACIDÆ, in their shape show a close approximation to the Caridea, but are distinguished from them by having the epistome united to the carapax, as it is in all the higher forms, while on the dorsal surface of the carapax is a transverse suture (wanting in the Caridea), which, as we have seen, is the remains of the joint between the antennal and mandibular somites. All three (and in the Eryoninæ four or five) of the anterior pairs of thoracic feet are terminated by a pincer, the first pair being very large, and forming the well-known "claw" of the lobster.

The Astacidae, so far as is known, differ from the rest of the Decapods in leaving the egg in nearly the adult condition, the zoeal stage being suppressed, the youngest larva being in the *Mysis* stage in the case of the lobster, while in the fresh-water crayfish the young differs in only unimportant details from the adult. The genera, of which about fifteen have been described, are distributed about equally between marine and fresh-water forms, and may be divided into two sub-families, the Eryoninæ and Astacinæ. The former, as has been stated, being characterized by four or five pairs of chelate feet, the latter by three. The Eryoninæ were long considered as an entirely extinct group, but recent deep-sea dredgings have brought to light several forms which have been described under the generic names of *Polycheles*, *Pentacheles*, and *Willemoesia*. The genus *Eryon* occurs fossil in the Solenhofen lithographic stone (Upper Oolite). The sub-family is exclusively marine.

The Astacinæ contains the crayfish and lobsters, or fresh and salt-water forms. Though several genera have been described, only *Cambarus*, *Astacus*, and *Homarus*, need here be mentioned. *Cambarus* and *Astacus*, our types of crayfish, differ from each other in only unimportant details; but the distribution of our American species presents an interesting feature. The genus *Astacus* occurs on the Pacific slope (and in Europe as well), while the waters which flow into the Atlantic contain only

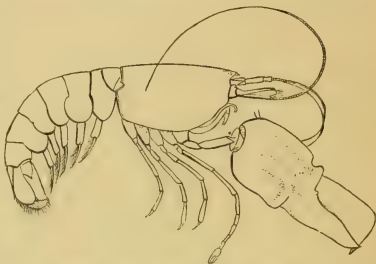


FIG. 62. — *Alpheus heterochaelis*, twice natural size.

individuals of the genus *Cambarus*. Many of our species, which have been described by Dr. Hagen, have burrowing habits, and are thus productive of considerable damage in mill-dams, and especially in the levees of the Mississippi. In Europe the crayfish are extensively used for food, as they are to a certain extent in our Southwestern States. In France there are several large farms for their propagation and cultivation, and when desired for the market they are captured by sinking in the water bundles of brushwood, in which the individuals become entangled and are brought to the surface.

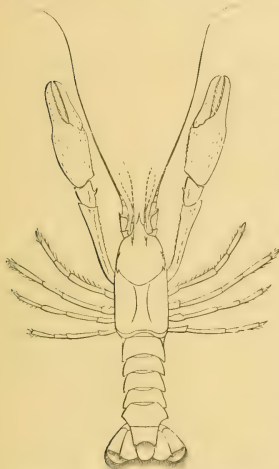


FIG. 63. — *Cambarus pellucidus*, blind crayfish of Mammoth Cave, natural size.

An interesting form is *Cambarus pellucidus*, the blind crayfish of Mammoth Cave and the neighboring caverns of Kentucky and Indiana. In these forms the eye-stalks remain, but the optical portions have almost entirely disappeared, — a good example of the effects of disuse, for in the total darkness of the subterranean streams the use of an organ of vision would be extremely slight. Dr. Packard has recently described a fossil crayfish from the Tertiary of our Western States.

To the New Englander the lobster is by far the most important member of the whole class of Crustacea. The genus *Homarus*, to which it belongs, contains three species, *vulgaris* of Europe, *capensis* from the Cape of Good Hope, and the *americanus* ranging from Labrador to New Jersey, and possibly even further south, Dr. Coues having found a single specimen near Beaufort, N.C. It frequents rocky bottoms, hiding among the stones, or occasionally varying its habitat for sandy or gravelly regions. Lobsters are very fond of decaying animal matter, and the nets and traps employed in capturing them are usually baited with fish offal. Two methods of lobster fish-

ing are in vogue. In one a large net, with the bait fastened in the centre, is lowered to the bottom, and after a sufficient time is hauled to the surface so rapidly that the lobsters have no chance to escape. The more usual means of catching these animals is by "lobster-pots." These are wooden frames usually constructed of laths with netting ends. In one or both ends is a small circular opening, through which the lobster passes to reach the bait on the inside of the pot. These pots are sunk in promising spots, their position being marked by a wooden float. Weather permitting, the pots are visited every day and hauled to the surface by means of the rope connecting the float to the pot. Frequently, when the character of the bottom permits, the pots are attached together in trawls, each end of the trawl line being marked by a float. The number of pots set by each fisherman varies, few using as many as one hundred. Possibly the average may be forty or fifty.

The lobster industry is very large, and we gather from the pages of Mr. Rath-

bun the following statistics: In 1880 the total catch on the Maine coast amounted to 14,234,000 pounds, valued at \$268,000, fishermen's prices; in Massachusetts 4,315,000 pounds, valued at \$158,000. Of the Maine catch the larger proportion was canned, the twenty-three canning establishments in that State taking about 9,500,000 pounds; while the Provincial factories put up an even larger amount. The quantity of lobsters handled by the several large fresh markets during 1880 was as follows: Boston, 3,637,000 pounds; New York, 2,500,000 pounds, and Portland, 2,000,000 pounds.

All of the interested States, with the exception of New Jersey, have passed more or less stringent laws regulating the time of catching and the size of the lobsters caught, those of Maine being the most lax. For several years past the average size of the lobsters caught has been decreasing, a specimen weighing four pounds being comparatively rare. Lobsters, however, are occasionally found much larger in size, there being one in the Museum of the Peabody Academy of Science at Salem, Mass., which weighed thirty-nine pounds.

The lobster, when about to moult, seeks some secluded spot under the shelter of a large stone, and there sheds his old shell. As a preparation for this act the lime salts in certain parts of the integument are absorbed, and then the carapax splits down the back, and through this opening the animal withdraws itself. As it would be impossible for the enormously developed claws to pass through the rigid joints of the arm, there is an absorption of the lime salts in these joints, and thus the claw is readily withdrawn. Together with the old shell, the lobster, like all Crustacea, sheds the lining of the stomach and of the posterior portion of the intestine. After moulting the lobster's skin is very soft, and the flesh soon becomes poor, watery, and flabby; but in a short time, by a deposition of calcic carbonates and phosphates, the new integument, which is larger than the old one, regains its former firmness, and in a few days the flesh acquires its former solidity and indigestibility.

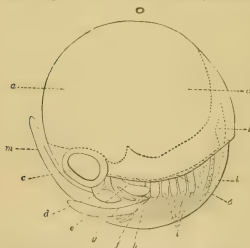


FIG. 64. — Embryo lobster some time before hatching, natural size above. *a*. Yolk. *b*. Margin of carapax. *c*. Eye. *d*. Antennula. *e*. Antenna. *g* to *i*. Thoracic feet. *k*. Intestine. *l*. Heart. *m*. Telson.

The breeding season varies according to the locality. In Long Island Sound the eggs are laid sometimes as early as the last of April or the first of May. In Massachusetts Bay the season extends from about the first of June to the first of August, while Professor S. I. Smith found at Halifax females with newly-laid eggs in September. For a knowledge of the development of our lobster we are indebted to Professor Sydney I. Smith, Mr. G. O. Sars having performed a similar work for the European species. The eggs, which for Crustacea are very large, are of a dark green color, and at the time of hatching, the embryo strongly resembles a *Mysis*, all of the thoracic feet being two-branched, while the external maxillipeds play a part in locomotion.

At the next stage the abdominal feet appear, and at each succeeding moult the young approaches more nearly the adult, retaining, however, their free-swimming habits until about half an inch in length.

The LORICATA differ anatomically from the group we have just left, by the absence of a scale on the basal joint of the antennæ, and in having the anterior pair of

Homarus vulgaris, lobster, and *Palmonurus vulgaris*, spiny lobster.



feet monodactyle, that is, not ending with a pincer, but in their development they present marked differences, the young forming the "glass crabs," which formerly, under the name *Phyllosoma*, were regarded as adults. These larvæ are flattened, hardly thicker than a sheet of paper, and in life are perfectly transparent, presenting not the slightest resemblance to the parents. The two families, SCYLLARIDÆ and PALINURIDÆ, are found in tropical seas, and are among the largest Crustacea. All of the feet, except the posterior pair in the female Scyllaridæ, are monodactyle, while the antennal scale is always lacking. The Palinuridæ are nearly cylindrical, while the Scyllaridæ are greatly flattened, the sides of the body being very thin. Both families are represented in our warmer waters by the genera *Palinurus* and *Panulirus*, *Scyllarus*, *Ibacus*, *Eribacus*, and *Arctus*.



FIG. 65. — *Phyllosoma*, glass crab, the larva of *Palinurus*, natural size.

The THALASSINIDEA, represented in our waters by several genera, are a burrowing group, the individuals of which, except from a scientific standpoint, are of but slight importance. While in the majority of forms the respiratory apparatus is of the normal character, it is said that in *Callinideæ* (of which one species occurs in the West Indies, the other extending from our west coast through all the eastern seas) and in *Calliniseæ* the abdominal feet also bear gills, thus presenting a resemblance to the Stomatopoda, to be described further on.

The GALATHEIDEA present us with a feature which we shall notice in connection with the Schizosomi, that the hinder pair of thoracic feet are carried bent up under the carapax, and in both groups, as in the Paguridea, the last thoracic segment is not immovably united to the rest, a feature which also occurs in the genus *Astacus*. *Grimothæa* is a pelagic form which occurs swimming at the surface in the Pacific Ocean, sometimes appearing on the Californian shores. *Eglea* is a fresh-water genus (the only one of the Anomura), and the single species occurs in the streams of Chili and Peru.

The last division of the Macrura which we have to consider is the PAGURIDEA, or hermit crabs. In these forms, with the exception of *Birgus*, the abdomen is always soft, the usual salts of lime not being deposited, and hence the animal inserts this defenceless portion of his body in the empty shell of some univalve mollusc. With this external protection there is usually an obsolescence of some of the abdominal feet, while the spiral character of the shell has caused the abdomen to become coiled in a similar manner. The posterior pair of abdominal feet are modified so as to form a hook, by means of which the crab holds himself into his house.

Many amusing accounts have been given of the habits of the hermit crabs, and we

can do no better than to quote the account which Dr. Lockwood gives of the little hermit crab, the *Eupagurus longicarpus*, so common on our eastern shores:—



FIG. 66. — *Eupagurus bernhardus*, hermit crab in a shell of *Lunatia heros*, natural size.

"Though a recluse,—for he lives in a vacated shell all alone,—yet of hermit gravity he has none. In fact, he is constitutionally a funny fellow. This crab has his two hands, or claws, greatly larger than the other feet, and of these the right one is much stouter than the left. The next three pairs of claws are tipped with simple hooks, which, having considerable leverage power, are really efficient grapnels with which to pull himself along when he travels, carrying his house on his back, while the claws of the fifth or last pair are very diminutive.

"There is a queer monkey-like drollery in the looks of our little hermit. We had one in our aquarium of rather large size, and which occupied a shell of the required capacity. Of this specimen we were very proud; the shell on its upper part was ashen white with a fine

colony of *Hydractinia*, like tiny sea-daisies. We had also a little hermit in a small *Ilyanassa obsoleta* shell. And what about this young scapegrace, whom we so soon almost wished obsolete? On he came and climbed right up into this pretty parterre, and having secured himself with his grapnels on top of his neighbor's house, most deliberately, now with the right claw and now with the left, he pulled off my weesome pets, stowing them into his ugly mug with a movement so regular that it seemed almost rhythmic, and yet so cruelly comical that it made me most laughably mad.

"But the hermit grows, while the shell which he occupies does not. Hence, like many bipeds, he has his "first of May," so he goes house-hunting. This must be understood literally. He finds a shell. Will it do? First, then, is it really to let? He will inquire within. This he does, if not most courteously, very feelingly. Satisfied on this point, the next question is, will the house suit. He turns it over, then turns it round. You see the weight of one's house is quite an item in the reckoning to him who has to carry it on his back. One inspection more. How is it inside? Is it entirely empty and of the right size? Up goes one of the slender limbs of the second pair, and the interior is thoroughly explored. All right! Just the house he is after. His mind is made up to move. Look at him! Quick! or you'll miss it! Out comes the body from the old house and pop it goes into the new one. The resolution to move was taken, the surrender of the old house was made, and the occupancy of the new was effected, and all within a fraction of a second of time.

"Sometimes this matter goes on less pleasantly. Two house-hunters may find the same tenement. Should both desire it, then comes the tug of war. Live together they neither can nor will. The affair is settled by a battle, in which the stronger proves his claim right by the Carlyleian logic and morals, viz. might. Quite often from these encounters a terrible mutilation results. To us it is a sad sight to see the little hermit when his time has come, and he knows it; that is, when *Eupagurus* must die. However droll his career may have been, the little hermit is grave then. And what a strange fact it is. Who can explain it? The poor little fellow comes out of his house

to die. Yes, in order to die. To us humans home is the only right place to die in. But for *Eupagurus* home has no attractions at this solemn time. Poor fellow, with a sad look and melancholy movement, he of his own will quits the house for which he fought so well. Those antennae, or feelers, that often stood out so provokingly, and were so often poked into everybody's business, now lie prone and harmless. The eyes have lost their pertness. There lies the houseless hermit on that mossy rock, stone dead."

In the above account Dr. Lockwood incidentally mentions the fact that the shell occupied by the hermit bears upon it a colony of Hydroids. Such associations are very common, and sometimes specimens are found even more interesting. In the deep waters off the New England coast a polyp (*Gemmaria americana*), allied to the sea anemones, attaches itself to the shells occupied by another species of *Eupagurus*, and by budding gradually covers the entire shell; and not only this, but it possesses the power of dissolving the shell so that no trace of it can be found. As this polyp increases in size with the growth of the crab, there is no need of

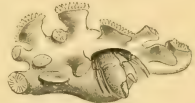


FIG. 67. — *Eupagurus* with its associated polyp.



FIG. 68. — *Coenobita diogenes*, natural size.

a change of house on his part,—his home grows as he does. Even more remarkable is the case of a Chinese hermit, *Diogenes edwardsii*, which always bears upon the outside of the large claw a small anemone, which, when the hermit retreats into his shell, closes the aperture. It occasionally occurs that the hermits fail to find a shell suitable to their needs, and then any object, such as an old bottle, is occupied. In looking over some Floridan Crustacea the writer once found a specimen of *Coenobita diogenes* which had thus occupied a "T. D." pipe.

The Paguridea are divided into two families,—**PAGURIDÆ** with fourteen genera, in which the antennulæ are very short, the species aquatic in habit; and the **CENOBITIDÆ** with long antennulæ and terrestrial habits, and represented by only two genera. One of these, *Birgus latro*, which is distributed throughout nearly the whole Indo-Pacific region, has received the popular name of Palm Crab. This form, which is an exception to all of the hermits in having the abdomen hardened, is said to feed on cocoanuts. Stripping off the husk, it inserts the tips of the claws into the three holes found in the end, and pounds the nut upon a stone until it is broken. Another method which they are said to employ for this purpose is as follows: The husk is stripped off, leaving but one or two fibres attached to the nut, then clasping these fibres the crab climbs a tree and then drops the nut on a stone. The coarse, fibrous husk is used to line the burrows which *Birgus* makes in the moist sand. When nuts are not to be had, the crab is not greatly averse to eating its own kind. The natives adopt a curious method of capturing these tree-climbing crabs. Watching until they see a *Birgus* ascend, they tie a lot of grass around the trunk of the tree at a considerable distance from the ground. By-and-by the crab descends, and feeling the grass thinks he has reached *terra firma*, and, therefore, looses his hold, and falling to the ground so maims himself as to become an easy prey to the savage. On a preceding page we have alluded to the lungs of this crab, but as the subject possesses much interest we may return to it again. The gill-chamber is divided into two parts, the gills being in the lower,

while the upper never contains anything but air. On the walls of the upper chamber are found numbers of ramified tufts, containing in their interior an extraordinarily developed network of vascular spaces, thus furnishing a large respiratory surface, while the arrangement of the blood-vessels conclusively proves that blood poor in oxygen enters it from the body, and the vessels leading from it open directly into the auricle.

In their development the Paguridea hatch as zoeæ, but from this point they closely resemble the Brachyura in the omission of a Mysis stage.

SUB-ORDER II. — BRACHYURA.

This group, which contains the crabs, the highest of the Decapods, possesses much more interest than any other division of the Crustacea. The body is generally broad and flattened, the carapax very seldom exhibiting the cylindrical form so characteristic of the Macrura. The abdomen is relatively small, and is almost always carried flexed under the thorax, which is frequently excavated for its reception. The antennæ are small (except in a few forms), and the inner pair frequently can be folded in small grooves or pits in the anterior part of the carapax. The external maxillipeds are opercular in character (that is, they form a sort of lid, covering the other mouth-parts) and rarely have but a distant resemblance to the ambulatory feet. The abdomen, as has been said, is small; the abdominal appendages are very rudimentary, and some of them

are frequently aborted. In many cases, especially in the males, two or more of the abdominal segments become coalesced, all traces of the sutures being occasionally obliterated. All of the Brachyura, except a few of the land crabs, leave the egg as zoeas, — the carapax being armed with three or, in the higher groups, four long spines. Of these one springs from the front of the carapax and points forwards, one arises on either side and is directed downwards and backwards, while the fourth, when present, is dorsal in position, a portion of the heart extending into it. The appendages at first present are but seven in number, the series ending with the second maxilliped, while the thoracic members are absent or very rudimentary. During the zoea stage the larva increases rapidly in size, the growth being accompanied by frequent castings of the shell, and the development of all of the series of appendages. Then by a single moult the megalops stage is acquired,



FIG. 69. — Zoea of *Carcinus*,
a. Natural size.

a schizopodal stage not intervening, a feature which, as we have seen, is shared by the hermit crabs among the Macrura. The Brachyura may be divided into the following groups: Schizosomi, Teleosomi, Maioida, Corystoidea, Leucosoidea, Cancroidea, and Grapsoidea.

The SCHIZOSOMI embraces the brachyuran forms which have the outlets of the ovaries in the bases of the third pair of legs instead of in the adjacent parts of the sternum, as in most Brachyura, and also the last thoracic segment free from the others. In some the abdominal appendages are well developed, in others they are rudimentary. So far as is known the zoeas do not develop a dorsal spine, but the other spines frequently are greatly elongated, and in the porcelain crabs these spines reach a length of several times that of the body.

The LITHODIDÆ, which in their form of body closely resemble the Maioid crabs, to be mentioned further on, are represented on our East coast by two species, the family acquiring its greatest development on the West coast of both North and South America. The abdomen is without caudal appendages, and at first sight it would appear that the name Decapods was a misnomer, as only four pairs of thoracic feet are externally visible, but a little investigation shows that the fifth pair are present, though folded up under the carapax. Of the habits scarcely anything is known.

The PORCELLANIDÆ are small, brightly-colored crabs, with a shell always kept clean, and from its general resemblance to porcelain giving the name to the principal genus. In these, as in the family just mentioned, the fifth pair of legs are not used in locomotion, being carried folded upon the back. The species, which are numerous in the warmer seas of the world, live under rocks or among the coral reefs. These forms are worthy of notice from a morphological standpoint, for it would seem that here the appendages of the seventh abdominal segment were partially developed, showing the validity of its recognition as one of the body segments.



FIG. 70. — *Petrodista armatus*, porcelain crab, natural size.

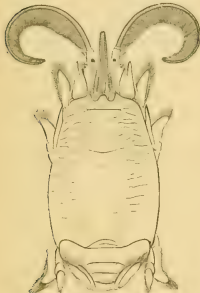


FIG. 71. — *Hippa emerita*.

The HIPPIDÆ have an elongate body, and feet fitted for swimming, while the way in which the abdomen is bent also fits it for burrowing. The following account of the habits of the American *Hippa emerita* is condensed from that furnished by Professor Smith: "This species prefers a narrow zone of sandy beaches, near low-water mark, where it lives gregariously, burrowing beneath the surface. They burrow with the greatest rapidity, and always backward, pushing themselves in by means of their thoracic feet. In an aquarium they at once plunged entirely beneath the sand, and then in an upright position showed just the tips of the antennulæ and the eyes at the surface. Of the food but little can be said. In all the specimens examined the alimentary canal was filled with fine sand, nearly free from organic matter, though under the microscope a small amount of vegetable matter is seen, rendering it

probable that the sand is swallowed for the nutritive matter it may contain."

The TELEOSOMI differ from the group just mentioned in having the last thoracic segment anchylosed to the others, as in most Decapoda, while the outlets of the female genital organs occupy the same position as in the group just mentioned. The first form we will notice is *Hypoconcha*, the "false hermit" of the older writers, of which three species are known in tropical American waters. In these forms the dorsal surface of the carapax is soft, resembling in



FIG. 72. — *Dromia*.

consistence the abdomen of the true hermit crabs, and, for protection, *Hypoconcha* takes a half of a bivalve shell, and inserting the angle of its abdomen in the depression beneath the hinge, holds the shell in position by the fourth and fifth pairs of thoracic feet. A similar habit has been noticed in the Chinese genus, *Conchevetes*. In some of the sub-genera of *Dromia* the crab carries in a similar manner a sponge, polyp, or compound ascidian.



FIG. 73. — *Dromia* covered with a sponge.

The remaining groups of Brachyura all have the female genital openings on the ventral surface of the body, between the bases of the feet, while in the zoeas a dorsal spine is almost universally present.

The MAIOIDEA or Oxyrhyncha, which in the older works were regarded as forming the highest of the Decapoda, and, indeed, of the whole Crustacea, are in reality the next in order; for although in some respects they have a high grade of structure, they, nevertheless, retain many embryonic features even in the adult stage, the young *Cancer*, for instance, at a certain portion of its development being strongly maioidan in appearance. The antennulæ are folded in longitudinal pits in the front of the carapax. The external maxillipeds are broad, the fourth joint being borne on the inner angle, or the summit of the third, while the carapax is usually elongate and triangular, being narrowed in front. The Maioida are divided into several families and over a hundred genera, the distinctions, however, being of too technical a character to suit a work like the present,—the systematic student being referred to the paper by Mr. E. J. Miers in the Journal of the Linnean Society for 1879.

Among the Maioids, interesting from their appearance, are the group of spider crabs, whose long and slender legs are greatly disproportionate to the body they have to support. These forms frequent the bottom, walking slowly and deliberately as though they had scarcely strength to move their attenuated members. Some of these forms keep their shell perfectly clean, seeming to rely upon their general resemblance to the Sertularians and other Hydrozoa, among which they dwell, for protection. Others, however, permit all sorts of



FIG. 74. — *Maia squinado*, natural size.

foreign bodies, both animals and plants, to become attached to their bodies, so that they are effectually concealed, and even when moving it seems as if a small forest of sea-weed were being transplanted to another locality. To these spider crabs the *Macrocheira* of Japan, the largest of all crustaceans, belongs. The

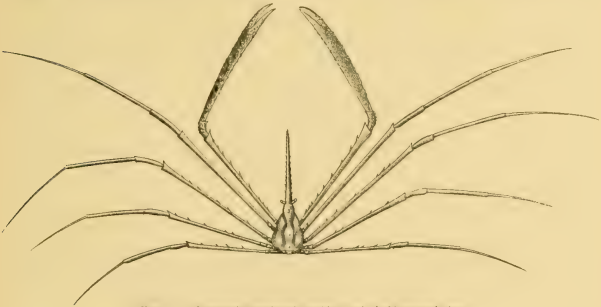


FIG. 75. — *Leptopodut sagittaria*, spider crab, half natural size.

relative proportions of legs to body in this species can be seen from the following measurements of a specimen captured at Yokohama in 1878, in which the legs extended to a distance of twelve feet, while the carapax was sixteen inches long by twelve in breadth. The largest specimen in any collection is said to be that in the British Museum, which measures between the tips of the first pair of legs eighteen feet, though larger specimens are occasionally taken, an old and trustworthy sea-captain telling the writer of one taken in 1871 which spread twenty-two feet.

The CORYSTOIDEA are entirely absent from the eastern coast of our continent, though present in all other seas. They have the antennulæ and maxillipeds much as in the Maioids, but differ in the longer antennæ and the very short epistome or region in front of the mouth.

The LEUCOSOIDEA or Oxystomata are extremely narrowed in front, the external maxillipeds, when placed together, forming a triangle. The carapax is more or less circular in outline, while the antennæ are very small, and the epistome wanting. In *Dorippe* we have a similar commensalism to those already noticed, one species of this genus never being found without a sea-anemone (*Cancerisocia expansa*) upon its back, nor has this anemone ever been found except in this position. In *Calappa* the sides of the body are expanded, while the two large claws, armed with strong spines above, are carried closely applied to the front of the body.

The CANCROIDEA or Cyclometopa agree with the Maioids in their mouth-parts, while the body is broader and the antennulæ are transverse. They are well divided

into two families, according to their habits, — the CANCRIDÆ having the feet constituted for walking, while in the PORTUNIDÆ the posterior feet are flattened and thus converted into efficient swimming organs.

The genus *Cancer*, which is represented on our eastern coasts by two species and by four on the Californian shore, may be taken as the type of the group. Our eastern species range from Labrador to the Bermudas, and by a curious mistake in nomenclature, the form to which the name *borealis* is applied extends further to the south and not so far to the north as does the more common *Cancer irroratus*. *Cancer irroratus* delights in secluded places under rocks, where it is safe from enemies and the pounding waves, while the stouter, heavier *borealis* disdains such protection, and occurs in places where it is exposed to the force of the waves. By many European naturalists these two forms are confounded, though in reality they are very

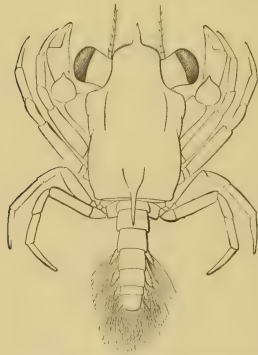


FIG. 76. — Megalops of common crab, *Cancer irroratus*.

- distinct, the teeth of the margin of the carapax being smooth in *C. irroratus* and crenulated in the other species. The European *Cancer pagurus* is used as an article of food both in England and upon portions of the continent, while none of our forms have much economic use. The genera and species of the Cancridæ are very numerous, especially in the warmer seas of the world, many being conspicuous by reason of their bright colors, though in habits no particular interest attaches to them. The mud-loving *Panopeus* of the warmer waters of both coasts of America is the only other species to which our space will allow us to refer.



FIG. 77. — *Panopeus depressus*, mud crab, natural size.

Merchus mermus, green crab.



As examples of the swimming crabs we may mention the "Green Crab," *Carcinus maenas*, which has a peculiar distribution, occurring on our coasts only from Cape Cod to Maryland, and on the European from Finmark down through the Mediterranean into the Black Sea. Besides these, its regular habitat, it has been reported from Brazil, Panama, the Sandwich Islands, and India. With its restricted distribution on our own coast, this wide distribution over the globe is of peculiar interest. Another of the swimming crabs, the *Neptunus hastatus*, furnishes the soft-shelled crab so well known to epicures. This crab, which extends along our Atlantic coast from Massachusetts to Florida, buries itself in the sand, exposing only its eyes and antennae. Like all of the Crustacea, it sheds its shell, and just after the moult it forms the delicacy of the table, the integument not then being hardened. At



FIG. 78. — *Platynechus ocellatus*, lady crab, natural size.

the time of moulting the flesh is hard, but in a few hours it becomes soft and watery, and then is of inferior quality. Only a few days are required to bring the new skin to its former consistency. Our figure of the lady crab, a beautiful species covered with rings of red and purple, will sufficiently illustrate the characters of the Portunidae, while the development is shown in figures 5, 6, 13, and 14, which represent the various stages of young of the soft-shelled crab mentioned above.

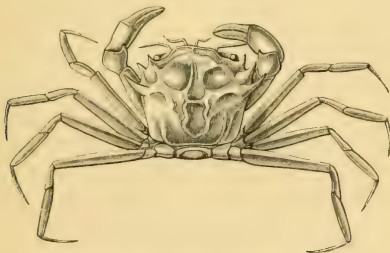


FIG. 79. — *Geryon tridens*, from deep water, North Atlantic Ocean.

The remaining division of the Decapoda, the OCYPODOIDEA or Catometopa, are the highest, both as shown by structure and by embryology. The antennulæ are transverse, the fourth joint of the external maxillipeds articulates with the apex or outer angle of the third; the body is broad, and, in the higher groups, quadrate in outline; the epistome is very short

and the male genital organs show a complication not found in other groups. In dividing the group into families authors show a considerable diversity of opinion, as the

number varies in different works from six to sixteen. It is not necessary here to discuss all of the families of the group, but merely to mention some of the more important forms. It is to the Ocypodoidea that the larger number of the terrestrial Decapods belong. An account of their respiratory apparatus has been given on a preceding page.

The PINNOTHERIDÆ are familiar to all in the little "Oyster Crab," *Pinnotheres ostreum*, so common in the oysters of our coast. Many tales are told of the way in which these forms act as guardians of the molluscs inside whose shell they dwell, and which have been perpetuated in the generic name, but which an iconoclastic science has shown to be false, these animals seeking this home merely for protection and for convenience of obtaining choice morsels of food in the currents of water created by the cilia on the gills and mantle of the mollusc. With our common oyster crab it is the female alone who thus keeps house, the male living a life of freedom, being very rarely seen. Other forms belonging to this or allied genera



FIG. 80. — *Pinnotheres ostreum*, oyster crab.

have similar commensal habits, some living in the shells of mussels or other bivalves, while one form from the Philippines is said by Dr. Semper to enter in the young state the water-lungs of the Holothurians and there spend its life, the carapax growing forward over the eyes, causing blindness or partial blindness, while the eyes themselves seem to undergo a more or less extensive retrogressive metamorphosis. A somewhat similar case is found in the Chilean *Pinnarodes chilensis*, which enters the anal opening of a sea-urchin, and sometimes occupies a third of the body-cavity of the host. It is one of the peculiarities of geographical distribution that the common *Pinnotheres pisum* of the English shores also occurs in antipodal New Zealand, occupying in both places what appears to be the same species of mussel. *Pinnira* is an aberrant form, some species of which live in the tubes of certain marine worms. In these the body is very short and broad, the breadth being occasionally three times the length. The two genera, *Harpalocarcinus* and *Cryptochirus*, belonging near the Pinnotheridæ, agree in having a sort of pouch for holding the eggs and young, formed by the lateral extension of the abdominal plates, and in living in coral where they produce structures recalling the galls produced upon plants by certain insects. *Harpalocarcinus* affects the branching forms, and, settling down between two twigs, stays there until by the growth of the coral he is rendered a prisoner for life, two small holes only remaining, through one of which he draws the water necessary for his existence, the other serving as an exit for the water which has served his purpose. The currents of water serve to keep the cavity open as long as the crab lives. *Cryptochirus* prefers to make his home in the more solid corals, where the young, settling down in the centre of a young polyp, kills it, while the surrounding polyps continuing to grow soon build a tubular dwelling for the crab.

Passing by the Grapsidæ, with its several hundred species, we come to a more interesting family, the Ocypodidæ. Here belongs the genus *Gelasimus*. In the males of this genus one of the claws is greatly larger than the other. When these crabs are disturbed their claws are brandished in an amusing manner, strikingly suggestive of the motions of a violinist, whence these forms have received the common name of "Fiddler Crabs." These crabs live in burrows in the ground near high-water mark, salt marshes being a favorite resort. One of these forms constructs an oven-like arch over the top of its hole, and there spends a large portion of his time, ready to descend to his underground home at the approach of an enemy. *Ocypoda* has a somewhat

similar habit of burrowing, but is much quicker in its motions. Our common *Ocypoda arenaria* is fond of "beach fleas" (Amphipoda), which it catches by lying in wait and springing upon them, very much as a cat catches mice.



FIG. 81. — *Gelasimus pugillator*, fiddler crab, natural size.

In the tropical regions of the globe are found the true Land Crabs, GECARCINIDÆ, which spend almost their entire life away from the water, only going to the sea at the breeding season. At all other times they frequent the mountains, running with great rapidity at the approach of an enemy.

ORDER IV. — STOMATOPODA.

The most important characters which separate this from the other orders of Podophthalmia may be briefly stated as follows: The carapax is smaller than in the Decapods, the first antennal and the last or last three or five of the thoracic rings being perfect and uncovered by the carapax. The ambulatory and raptorial feet are seven in number, the two external maxillipeds of the Decapoda here being enlarged and losing their functions as mouth-parts, thus showing an approach to the Edriophthalmia. The five anterior pairs of these feet are furnished with an imperfect pincer, the last joint closing upon the preceding one. These three posterior feet are all bifurcated or schizopodal in character. In the gills also we notice important features, for these organs instead of being carried upon the bases of the thoracic feet, and projecting into a respiratory chamber, are borne upon the first five pairs of abdominal feet, and hang freely in the water. The heart, instead of being a small and compact thoracic organ, as in the Decapods, here is a long, slender tube, extending the length of the abdomen. The principal venous sinus, as would be inferred from the location of the gills, is also abdominal. The nervous system is formed upon the usual arthropodal type, and the abdominal ganglia are united by double commissures, which have not been united as in the Decapods.

The early phases of the development of the Stomatopoda have not been studied. The eggs are laid in burrows in the bottom of the sea, and from this to the *Alima* stage nothing is known. Fritz Müller, Claus, and Professor W. K. Brooks have studied the development of this order from this point on, the results of which are here

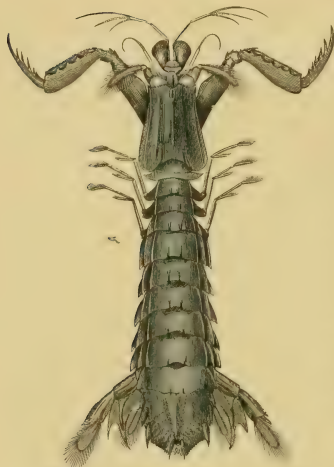


FIG. 82. — *Squilla empusa*, mantis shrimp, reduced.

racic segments appear. In the *Alima* type of development, which has been followed through by Professor Brooks, it seems probable that the young leaves the egg in nearly the *Alima* form, and in the youngest stage known the six appendages, eight to thirteen, are absent, although three of the corresponding segments of the body are developed, while the abdominal segments and their appendages are well developed. None of the thoracic members are biramous. From this, which corresponds to the *Erichthus* after the atrophy of the appendages, a regular development produces the adult form.

There are two well-marked genera of Stomatopoda, *Squilla* and *Gonodactylus*, the former being divided into several sub-genera. Thirteen species of the Squillidæ are found in American waters, *Squilla empusa* extending as far north as Newport, R.I., where it burrows in the mud, forming large irregular holes. The colors are very bright, — green, red, yellow, and black predominating. The large pincer in both genera is formed by the last joint of the leg folding upon the

greatly condensed. There are two types of development, one passing through the forms which were formerly considered as adult, and described as *Erichthus* and *Squillerichthus*, the others through an *Alima* stage, with the probabilities that the former represents the larva of *Gonodactylus*, the latter certainly that of *Squilla*. In the youngest known *Erichthus* type we have both stalked eyes and a single median ocellus, while the first ten pairs of appendages are developed, the sixth to tenth being biflagellate. Behind these are three segments of the body without appendages. A large carapax covers the anterior portion of the body, and is prolonged into a spine in front. Afterward the last three maxillipeds become aborted, and then grow out again in their permanent form. The abdominal feet develop in succession from before backward, and all are fully formed before the appendages of the three posterior tho-

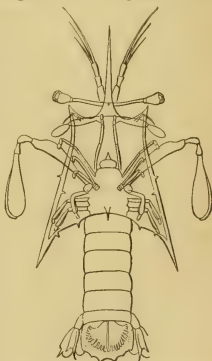


FIG. 83. — Advanced larva of *Squilla empusa*, enlarged.

preceding joint, and in *Squilla* this claw is armed with strong teeth or spines, which are wanting in *Gonodactylus*, which is represented by a single species, *G. chiragra*, in the warmer waters of the Southern States, as well as other parts of the world.

ORDER V. — CUMACEA.

But little popular interest attaches itself to this order, which is represented by only a few small species. Their exact position is a matter of doubt, though their embryology shows them, as pointed out by Dohrn, to be intermediate between the Podophthalmia and Edriophthalmia. The carapax covers only the first six cephalothoracic rings, and is followed by twelve segments, mostly without appendages. The telson is pointed, but does not extend as far as the appendages of the preceding segment. The anterior cephalothoracic appendages (excepting the mandibles, which are without palps) are two-branched, but in the three posterior pairs the exopodites are wanting. The abdominal appendages are better developed in the males than in the females, and in the early days of science this difference between the sexes led to the establishment of genera which had no real foundation. The organ of vision consists of a single (or two closely approximated) sessile eye in the median line on the front of the body. The respiratory organs consist of branchial plates attached to the first thoracic appendage.



FIG. 84. — *Diastylis quadrispinosa*, enlarged.

Besides the differences already alluded to, the sexes may be further distinguished by the antennæ; these in the females are smaller than the antennulæ, while in the males they are very long. In the females plates arising from three of the thoracic segments form a brood-pouch similar to that which has already been described in the opossum shrimps. In this pouch the eggs undergo their development, hatching in nearly the adult condition. In the flexure of the body, and in the possession of a "dorsal organ" (a structure of unknown functions), the early embryos show a decided approach to the Edriophthalmia, but later in life they more nearly resemble the Decapods.

Several species are common on the Eastern shores of the United States, frequenting muddy bottoms. They creep about, using the end of the tail to push themselves forward; or, folding the tail over the back, they swim with great facility. Their colors are usually dull, though they are occasionally ornamented with more marked tints.

J. S. KINGSLEY.



FIG. 85. — Side view of *Alima* stage of *Squilla empusa*, enlarged.

SUB-CLASS IV. — EDRIOPHTHALMIA.

This group of Crustacea, which derives its name from its sessile eyes, in contradistinction to the Podophthalmia, with the organs of vision seated upon movable stalks, is also known as Tetradecapoda, or fourteen-footed Crustacea. These forms, which are mostly small, possess but very slight popular interest, for but few of them are either markedly injurious or beneficial, and their habits are not such as to attract much attention. From a scientific standpoint they also possess but few attractions, for their structure and their mode of development present but slight variations except in minute details.

The group is characterized by a body never consisting of more than twenty segments, though frequently, by abortion or coalescence, even less than this number are seemingly present. The segments which enter into the composition of the head are always united, but those which correspond to the thorax of the decapods are never entirely covered by a carapax; from four to seven segments of this region being always free and uncovered. The abdominal segments are frequently reduced in number. The normal appendages of the body are two pairs of antennæ, a pair of mandibles, two pairs of maxillæ, and but one pair of maxillipeds. Next in order are the seven pairs of walking feet, while the abdomen bears six pairs, which are frequently adapted for swimming. We here notice a difference from the Podophthalmia in the number of walking feet, which is occasioned, as is readily seen, by the transfer of the last two pairs of maxillipeds from the mouth parts to the ambulatory series. The eyes are usually sessile, though in forms like *Manna* they are seated on movable stalks, or, as in some other forms, they may be entirely absent.

The respiration is usually effected by means of gills, but in some few degraded forms these organs are entirely wanting. The gills, when present, are borne either beneath the thorax (amphipods) or the abdomen (isopods). Among the former the gills take the shape of membranous sacs, attached to the bases of some of the walking feet, while in the latter the inner branch of the abdominal feet becomes modified for respiratory purposes. Frequently, in the Isopods, five pairs of these gills are developed, the anterior pair of abdominal feet forming a door, or opereulum, which closes in the others, the rest of the wall of the gill cavity being formed by the lower surface of the body. In the terrestrial Isopoda, however, but three pairs of gills are thus developed.

The heart is an elongated, many-chambered organ. The alimentary canal is short and straight, and in some forms vessels empty into the intestine near its termination. In the stomach is found a triturating organ, and a straining apparatus similar to that of the Podophthalmia. The liver is usually large, and empties into the alimentary tract by several mouths.

The eggs, after impregnation, undergo their development in brood-pouches beneath the thorax, similar to those which we described while treating of the opossum shrimps. In the embryology we miss the startling changes which we have seen in the other groups of the Crustacea, for the



FIG. 86. — Embryo of *Gammarus*. *m*. Micropyle. *y*. Yolk. *b*. Brain. *l*. Labrum.

Edriophthalmia have a direct development without metamorphoses, hatching from the egg in the perfect form. There is usually a partial segmentation of the egg, followed by the formation of an embryonic disc, and the subsequent out-budding of the limbs. In connection with the embryonic state there is developed on the dorsal portion of the body a peculiar structure, the so-called micropyle, or dorsal organ, the functions or signification of which are entirely unknown.

The Edriophthalmia are divided into two well-marked orders: Isopoda and Amphipoda.

ORDER I. — ISOPODA.

The name of this order signifies equal feet, and was given from the apparent similarity of the locomotive members. Strictly speaking, it does not fully apply to all of the individuals of the group, for in several forms (for example, *Astacilla*, from our own shores) the walking-feet are not so uniform as the name would indicate. The Isopoda are usually flattened (depressed) forms, occurring either in the sea, in fresh water, or on the land.

The antennulæ lack the secondary flagellum so common among the Decapods; the mouth parts, four in number, are strong and well developed. The legs are, for the most part, small, and more or less uniform in shape, terminating in hook-shaped claws, a chelate condition being comparatively rare. From this uniform structure of the ambulatory members variations may be noticed in many directions, to which we shall recur in treating of the various families. In the female Isopoda the legs bear at the base a series of membranous plates, each extending horizontally toward the leg of the other side, thus forming, with the under surface of the body, a brood-pouch, in which the eggs undergo their incubation.



FIG. 87. — Transverse section of *Porcellio*, showing brood-pouch. *a*, Plates enclosing *c*, brood cavity. *l*, Legs.

The abdomen is well developed, but the segments of which it is composed are frequently fused together to a greater or less extent, all being distinct, — for instance, in *Lygia*, while in *Asellus* the sutures have almost entirely disappeared. The first five pairs of abdominal limbs play no part in locomotion, but are developed into broad foliaceous membranous plates, specialized for respiratory purposes. The last pair always differ from the others, and either form a cover to protect the respiratory plates closing over them like folding-doors, or, as is rather more usual, retain more or less of the functions and structure of the other locomotive limbs.

In internal anatomy we have nearly the typical structure of the Crustacea, the variations being comparatively few, and unimportant. The development is direct, the young hatching in nearly the form of the adult, or occasionally with a smaller number of segments and appendages.

The Isopoda are, to a large extent, carnivorous, living almost wholly upon animal substances. Among them we find a number of parasitic forms, which live on the skin, among the gills, or in the mouth of fishes, while others affect other Crustacea. The greatest number are found in the sea, where the service they do in consuming decaying animal matter is inestimable. The fresh-water forms are less numerous, while the whole family Oniscidae, or



FIG. 88. — *Spharona quadridentata*, enlarged.

"sow-bugs," live on the land. The Isopoda are usually divided into two groups, named, respectively, Ambulatoria and Natatoria, according to their walking or swimming habits, with which are correlated many anatomical features. We will here, however, omit these two larger divisions, and proceed at once to the discussion of the families.

The first of these families, the TANAIIDÆ, is of doubtful position, but, according to Fritz Müller (whose opinions are seconded by other authorities) they probably represent an ancestral type of Isopoda.



FIG. 89. — *Leptochelia algicola*, enlarged twenty times.

They differ from all other Isopoda in having the respiratory organs beneath the head and first thoracic segment, the eyes, when present, upon jointed stalks, while the abdominal appendages have no respiratory function, and the first pair of ambulatory feet are chelate. In their embryology the Tanaidæ are said to present points of resemblance to *Asellus*, *Lygia*, and *Cuma*. But two genera, *Tanais* and *Leptochelia*, are represented, so far as is known, upon our shores.

In the GNATHIIDÆ we find a type more allied to the normal isopod. The thorax apparently consists of five segments, and only five pairs of limbs possess the normal form. In the typical genus *Gnathia* (*Praniza* and *Anceus* of authors) there is a great difference between the males and females, so great, in fact, that different sub-families have been erected for the two sexes of the same species. The larvæ are more nearly like the normal isopod than are the adult. A single species, *G. cerina*, is found on the New England coast.



FIG. 90. — *Gnathia*, male.

Passing the ANTHURIDÆ, a small group of slender forms, the next families to be noticed are the CYMOTHERIDÆ, ÆGIDÆ, and CIROLANIDÆ, which embrace most of the parasitic forms of this order. Yet the parasitic



FIG. 91. — *Gnathia*, female.

habits have not produced such a profound effect upon the structure as among the root-barnacles and the Siphonantia, already described. From their habits the term "fish lice" is eminently appropriate for them, as they live attached to the integument or within the mouth of fishes. Usually these three families are considered as one, under the name Ægidæ. They all agree in having all of the segments behind the head distinct, and in the lack of an operculum closing in the respiratory cavity.

Among the more interesting forms belonging to this family may be mentioned *Æga psora*, the "salve-bug" of the fishermen, which is frequently found attached by its sharp claws to the cod and halibut, and *Cymothoa prægustator*, which occurs attached to the roof of the mouth of the menhaden. Mr. J. F. Bullar has shown that in certain genera (*Cymo-*



FIG. 92. — *Æga psora*, salve-bug

thoa, *Nerocila*, and *Anilocra*) a peculiar type of hermaphroditism occurs. The young, at a certain stage of development, have well-developed male organs, and also ovaries, but the oviduct has no external opening. Later in life the male organs are lost, while the oviduct communicates with the exterior and the brood pouch is developed. It has further been shown that these forms are incapable of self-impregnation.

The little wood-boring *Limnoria* has a family (LIMNORIDÆ) all to itself. Small as it is this little form does a great amount of damage to wharves and shipping. Whenever wood is submerged beneath the salt-water these *Limnoria lignorum* are apt to be found. The mandibles have sharp cutting-edges, and with them the *Limnoria* eats its way into the wood, their immense numbers making them very destructive. Many plans have been proposed for preventing the ravages of the gribble, as it is commonly called, but none of them have proved very successful, and at the same time cheap. Possibly the best is the impregnation of the wood with creasote, or "kyanizing." *Limnoria* occurs in the waters of Europe and America, and on our Pacific coast is said to do a great deal of damage, especially in San Francisco Bay.



FIG. 93. — *Limnoria lignorum*, gribble.

The IDOTEIDÆ is the largest of the isopodan families, as well as the best known. The body is usually long and slender, while several of the abdominal segments are united into a large caudal plate. In this family the operculum of the respiratory cavity acquires its most perfect condition.

The genus *Idotea* is the most prominent in the family, and our common *I. irrorata* has a very extended distribution in the northern hemisphere. It varies greatly in color, closely resembling in this respect the rocks and weeds among which it dwells. It is very abundant in tidal pools along our northern Atlantic coast. Less common is *Idotea phosphorea*, which has the same habits, but which is especially noticeable from its phosphorescent powers. Our two species of *Chiridotea* (*cæca* and *tuftsi*) are much broader than the typical forms of the family. They live burrowing in the sand from near high-water mark to about twenty-five fathoms. The name of the first species is not very appropriate, for it is not blind.

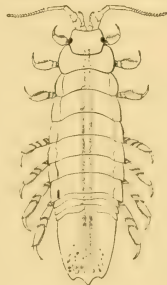


FIG. 94. — *Idotea irrorata*, enlarged.

Passing by the MUNNOPSISIDÆ, a small family of blind marine Isopoda, we come to the ASELLIDÆ, the members of which are found in both salt and fresh water. The abdominal segments are united, the legs are fitted for walking, while the eyes may be present or absent. *Asellus* is the typical genus, and its members are common in the fresh waters of Europe and America. A blind form, described under the generic name *Cæcidotea*, occurs in the waters of the caverns of Kentucky and Indiana.

The BOPYRIDÆ embraces forms which are parasitic on other Crustacea. By their parasitic habits the females have become greatly altered in shape, frequently losing many of their appendages. They usually inhabit the branchial chamber of decapod Crustacea, attaching themselves to the gills and sucking the juices of their

host. The males are much smaller than the females, and have not been so extensively altered by parasitism. They usually are found attached to the modified abdominal feet of the females. These forms have not been exhaustively studied, and comparatively little is known of our American forms. The principal characters separating the genera are the number and shape of the abdominal branchial feet.

The last family of Isopoda which we have to notice is the ONISCIDÆ. The forms belonging here are almost entirely terrestrial, for although some of them may be found on the seashore they are not aquatic in their habits. The antennulæ are minute, but the antennæ have from six to nine joints, the differences in number affording important systematic characters. The legs are all fitted for walking, while the abdomen is composed of six distinct segments. In common parlance these forms are known as "sow-bugs," "pill-bugs," and "wood-lice." They live in damp situations, — in cellars, under decaying wood, etc. In *Armadillo* and its allies the body can be rolled up in a compact ball, recalling the similar capacities of the mammalian genera *Tatusia*, *Dasy-pus*, and *Tolypentes*. The more common forms, belonging to the genera *Oniscus*, *Porcellio*, etc., usually do not have this capacity. These forms are largely if not entirely vegetable feeders, devouring much which would become offensive or injurious to man. In olden times, when the more disgusting a thing was the more efficacious it was considered as a remedial agent, some of these "sow-bugs" played an important part in the Pharmacopœia, but doubtless they had very little therapeutic value.



FIG. 95.—*Porcellio*, sow-bug, enlarged.

ORDER II. — AMPHIPODA.

As a rule the members of this order present a very strong contrast to those of the Isopoda. These have the body flattened vertically, the legs, as the name indicates, divided into two dissimilar series, while some frequently terminate in a more or less perfectly formed pincer. They are not so largely modified by parasitic habits, while their mouthparts are less variable than in the group which we have just left. The gills are in the form of sacs attached to the bases of the thoracic limbs. The sessile eyes are compound, but the investing integument is not faceted. The antennulæ are sometimes two-branched, and the mandible usually bears a palpus. The two anterior pairs of walking feet are usually fitted for grasping, sometimes bearing a pincer as perfect as those found in the Decapoda. Moulting is effected by a transverse fissure just behind the head, and a longitudinal one extending from this down the back. The individuals have not that power of amputation of members which has been noticed in connection with certain Decapoda.

SUB-ORDER I. — LÆMODIPODA.

In the older works the forms included under the name Læmodipoda were regarded as belonging to the Isopoda, the next view placed them as an order intermediate between the Isopoda and the Amphipoda, while more recently the weight of authority is in favor of the position here accorded them. In these aberrant forms the most striking characteristic is the rudimentary condition of the abdomen, which is represented by an inconspicuous tubercle without appendages. The number of thoracic

feet varies from five to seven, and the branchial sacs are attached to the first four segments, or to only one or two of them.

The CAPRELLIDÆ are long and slender forms, with well-developed antennæ and antennulæ. They live in salt-water, walking around on submarine plants in a very deliberate manner, and progress by a doubling-up of the body in about the same way that the measuring worm does, and the most common species on the Atlantic coast, received its name (*Cuprella geometrica*) from this habit.



FIG. 96. — *Caprella geometrica* on a branch of Polyzoa.

The other family of this sub-order has received the name CYAMIDÆ, from its leading genus, *Cyamus*. These are the whale-like which live attached to the skin of whales. Each species of these marine mammals probably has its own species of parasite. They are small forms, a quarter or a half an inch in length, with rudimentary antennæ, five pairs of feet, and two pairs of branchial sacs attached to the third and fourth segments



FIG. 97. — *Cyamus ceti*, whale-louse, enlarged.

of the body. The size of these sacs exhibits much variation; in *C. ceti* they equal the longest of the limbs in length; in other forms they are proportionately much shorter.

SUB-ORDER II. — AMPHIPODA GENUINA.

This group contains the numerous forms in which the head is clearly distinct from the first thoracic segment, and which have the abdomen well developed, and composed of from five to seven segments, most of which bear appendages.

Our first family, OXYCEPHALIDÆ, embraces a few long and slender forms found on the high seas. The head is greatly elongate, and the feet do not have the basal joint expanded. The peculiar features acquire their greatest development in *Rhabdosoma*,



FIG. 98. — *Rhabdosoma batei*, enlarged.

of which we figure a species from the middle of the Pacific ocean. None have been recorded from either coast of the United States. These forms swim by doubling the body, and then suddenly extending it.

In the family PHRONIMIDÆ the antennæ are absent, at least in one sex; while the antennulæ are well developed, the maxillæ are more or less rudimentary. *Phronima*, the typical genus, is a sort of hermit among the Amphipoda; for it lives in the dead tubes of *Beroë*, *Pyrosoma*, and other similar pelagic forms. A species occurs in our waters. Near *Phronima* and *Hyperia* is to be placed the large Amphipod, *Thaumops pellicula*, which was taken by the "Challenger" expedition off Gibraltar, at a depth of nearly twelve hundred fathoms. It is perfectly transparent, and receives its

generic name from its remarkable optical organs, the facets of which cover the whole of the upper surface of the head. *Cystosoma* is a closely related form, which was

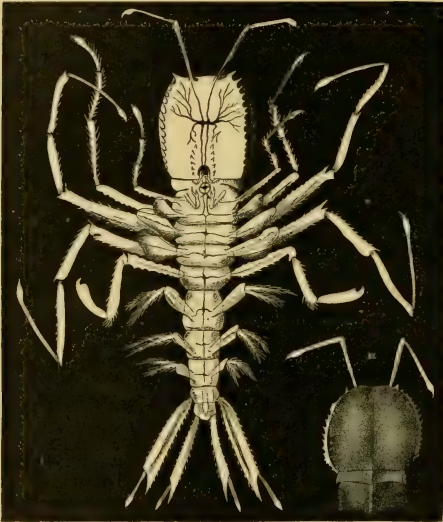


FIG. 99. — *Thaumtops pellucida*, a little reduced. a. Upper surface of head, showing the large eyes.

found off the Cape Verdes, at a depth of fifteen hundred fathoms. For these two forms a family, CYSTOSOMIDÆ, has been erected.

The HYPERIDÆ are represented on our coast by two or more species, which possess commensal habits. One of these inhabits the genital folds of *Aurelia*, *Cyanea*, and other jelly-fishes, but it is not compelled to stay there, for it is a good swimmer, and leaves its host whenever it wishes. All of the forms belonging to this family have a very thin integument, which is free from hairs; the antennulæ are present in both sexes; the eyes are very large.



FIG. 100. — *Hyperia*, enlarged.

They are found in all parts of the world, and many have the same habits as the species mentioned above, some affecting jelly-fishes, others living with *Salpæ*, etc. Some of the European species find a home in

the dead tests of *Doliolum* (one of the ascidians), in which they dwell much after the fashion of hermit crabs, while *Beroë*, one of the jelly-fishes, furnishes a habitation for others.

The family CHELURIDÆ contains but a single species, *Chelura terebrans*, which has several of the abdominal segments united, while the last three abdominal feet are

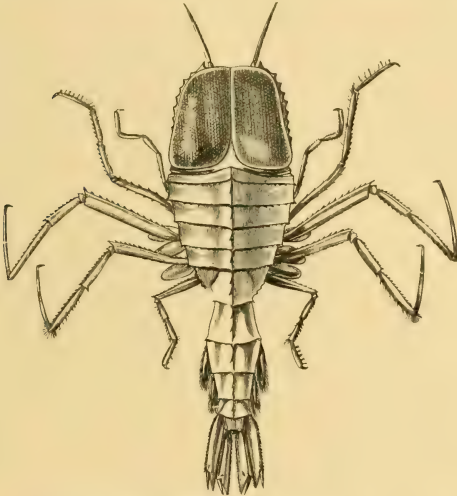


FIG. 101. — *Cystosoma neptuni*, slightly reduced.

greatly modified from the usual type. This species is, next to *Limnoria*, the most destructive of all Crustacea. The animal only reaches a length of about a third of an inch, but its immense numbers make up for the diminutive size. Like *Limnoria* they excavate burrows in the hulls of ships, the piles of wharves and bridges, and any other submerged timber. It is in Europe that this species has caused the greatest damage; it is almost unknown in this country, as it has only been seen in our waters in a few isolated cases.

The COROPHIDÆ is a much larger family, represented in our waters by many species. The forms are largely dwellers in tubes, which they either form for themselves or find in the deserted homes of marine worms, etc. Many of the species



FIG. 102. — *Cerapus rubricornis*, female; below the pincer of the male, enlarged.

have peculiar glands in their legs, which secrete a substance which binds together the sand and mud in which they dwell into a tube. The members of the genus *Amphithoë* construct such tubes, which they attach to the under surface of stones, while the species of *Cerapus* carry their dwellings about with them much after the fashion of caddis-fly larvæ. *Unciola* does not build a tube, but takes any that it may find vacant. All of these forms have the power of leaving their tube; but, for the most part, they are content to stay at home, their heads projecting from the opening, and all of their sense organs on the alert for any passing morsel of food.

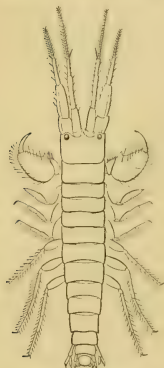


FIG. 103. — *Unciola irrorata*, enlarged.

The GAMMARIDÆ is the largest in number of species of any of the Amphipoda. Like the last its members are aquatic, and when removed from the water they endeavor to travel lying upon their sides, but the attempt is not very successful. When placed beneath the water they are at once in their element, and swim with ease, or buoyed up by that medium they walk in an upright position. Their swimming is mostly done upon the back or side, and is a rapid but somewhat corkscrew-like motion. They have the antennulæ large, and frequently bearing a secondary branch. The species are mostly marine, only a few being found in fresh water.

The most prominent genus is *Gammarus*, numbers of which abound among the *Fucus* or rock-weed on our shores, and in most of our inland lakes and rivers as well. They do not venture out into the open water, but remain mostly among the vegetation along the shores. Others dwell in or on the mud at the bottom. Of their habits scarcely anything of popular interest can be said; but though uninteresting they are far from unimportant, for their vast numbers render them very prominent in the food supply of fishes.

The members of the family ORCHESTIDÆ are the most terrestrial of the Amphipoda, and, although never found but a short distance from the water, there are several species which will die if kept too long in that element. These forms are familiar to those who have spent much time at the seashore, as the "beach-fleas" so common on the sandy beaches.

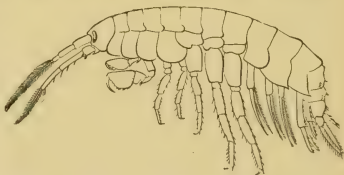


FIG. 104. — *Gammarus ornatus*, enlarged.

The ordinary observer, however, has but a very slight idea of their real abundance. If he will turn over some of the sea-wrack (the dried seaweed, etc.) which forms long windrows along the sand above high-water mark, he will have some conception of the incalculable number of individuals. When the weather becomes so warm that the windrows no longer retain their moisture, the Orchestidæ burrow into the sand. From their habitat these forms are of slight importance as a fish food, but they play their part in the economy of nature by devouring all decaying animal and vegetable matter

which comes in their way. While they furnish many a meal for the shore birds, the tiger beetles consume an immense amount of them.

In speaking of the amphipods, Professor Verrill says: "These small Crustacea are of great importance in connection with our fisheries, for we have found that they, together with the shrimps, constitute a very large part of the food of our more valuable edible fishes, both of fresh and salt waters. The amphipods, though mostly of



FIG. 105. — *Orchestia agilis*, beach-bea, enlarged.

small size, occur in such immense numbers in their favorite localities that they can always be easily obtained by the fishes that eat them, and no doubt they furnish excellent and nutritious food, for even the smallest of them are by no means overlooked even by large and powerful fishes, that could easily capture larger game. Even the voracious blue-fish will feed upon these small Crustacea where they can be easily obtained, even when menhaden and other fishes are plenty in the same localities. They are also the favorite food of trout, lake whitefish, shad, flounders, scup," etc.

The Edriophthalmia make their appearance in the coal measures of Europe and America. These early forms are amphipodal in their general appearance, but in many details they resemble some of the true shrimps. The coal-measures of Illinois are especially rich in these forms.

J. S. KINGSLEY.



FIG. 106. — *Amphithoe maculata*, enlarged twice.

ARTHROPODA OF DOUBTFUL POSITION.

As was mentioned on a preceding page, there are several groups of jointed-footed animals the position of which, in the branch of Arthropoda, is very uncertain. No one has yet conclusively proved that any of these forms belong to either the crustaceans or to the insects, and it may possibly be ascertained that some at least are to be considered as equivalents to the groups just mentioned. With this great uncertainty we have considered it advisable to place these forms in an intermediate position between the Insects and Crustacea, and in their treatment to omit the terms class, sub-class, and order, except in one group where it seems that their use is warranted. With the exception of *Limulus*, the living forms are generally small and not of frequent occurrence,—facts which in part explain the uncertainty which exists regarding their systematic position.

PYCNOGONIDA.

The “Sea Spiders” form a problematical group which agrees with the true Arachnida in the possession of eight pairs of legs, but they present so many points of difference from them, and indeed from all Tracheata, as to justify Dr. Hoek, their latest student, in regarding them as a class. The body is always small, and is divided into four segments, the anterior of which has received the name of cephalothorax. To this is attached a proboscis, which has recently been shown to be not the united chelicerae and pedipalps, as was supposed by Professor Huxley. Behind the proboscis are three pairs of appendages,—the mandibles, palpi, and ovigerous legs. Sometimes the first two pairs are lacking in the adults, but the ovigerous legs are always present, and only one exception is known to the rule that the male bears the eggs attached to these limbs. On the dorsal surface

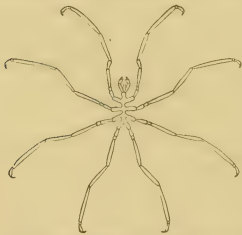


FIG. 107. — *Phorichilidium maxillare*, sea-spider, twice natural size.

of the cephalothorax is a small prominence known as the oculiferous tubercle, which bears the four simple eyes. These eyes, however, are occasionally rudimentary or absent, especially in the deep-sea forms.

The thoracic portion of the cephalothorax, and the three thoracic segments, bear four pairs of walking feet, each supported on an outgrowth from the body. The legs are long, frequently many times the length of the body, and are eight-jointed. The last thoracic segment also bears the rudimentary abdomen, which is occasionally articulated.

The nervous system consists of a brain and five (rarely four) infra-oesophageal ganglia, connected by commissures. From the brain nerves go to the eyes, mandibles, and upper portion of the proboscis; from the first ganglion behind the oesophagus, the lower portion of the proboscis, the palpi, and ovigerous legs are innervated. The other ganglia supply the legs. The digestive system presents some interesting peculiarities.

A short œsophagus opens into a muscular enlargement, the walls of which are lined with chitinous projections, the whole presenting a strong resemblance to the anterior portion of the stomach of the lobster. From this stomach a tube of varying length goes to the anus. From this tube arise elongated pockets or cœca, varying in number from four to six pairs, which enter, to a greater or less extent, the proboscis, mandibles, and legs. The heart is a short tube, which has usually three incurrent apertures, while the blood by its action is forced forward through an anterior excurrent orifice into the spaces between the muscles and the viscera, there being no arteries or aorta present. Respiration is effected through the general surface of the body, there being no specialized organs for the purpose.

The sexes are always separate. The genital organs are lodged in the ambulatory legs, and have their openings in the basal joints. The eggs are impregnated after emission, and are transferred to the ovigerous legs of the male, where they are enveloped in small sacs. The eggs undergo a total segmentation, and usually hatch with the proboscis, palpi, mandibles, and three pairs of legs developed, though some species have only one pair fully developed, and others have four



FIG. 108. — Galls and young of *Phorichilidium*, enlarged.

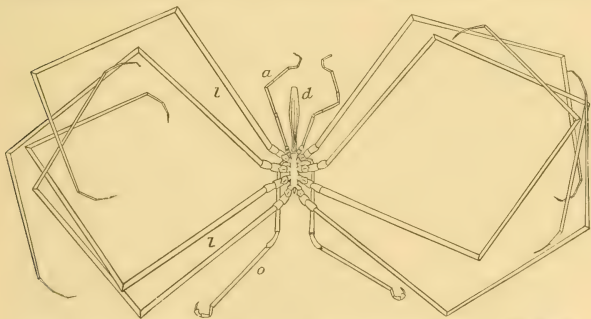


FIG. 109. — *Colossendeis colossea*, one-half natural size. *a.* Palpi. *d.* Proboscis. *l.* Legs. *o.* Ovigerous legs.

at the time of leaving the egg. The young of the genus *Phorichilidium* live a semi-parasitic life within the digestive cavities of certain tubularian hydroids, where they form what may be called galls.

Pycnogonids are not rare on our coasts, and may be sought for on *Campanulariæ*

and other hydroids, as well as sponges. The dredge frequently brings up specimens. About thirty species are known from American waters.

About a hundred and fifty species of pycnogonids have been described, divided into about thirty genera and four families. In the first of these families, PHOXICHILIDÆ, the mandibles and palpi are rudimentary or absent, and the ovigerous legs are usually present only in the male. The PALLENIDÆ have the mandibles well developed, the palpi rudimentary or absent, while the ovigerous legs are occasionally absent in the female. The COLOSSENDEIDÆ reverse the features of the last family, as they have the mandibles rudimentary or absent, while the palpi are present. This is the largest family both in genera and species, and in the size of some of its species as well, the form which we figure occasionally spreading twenty-one and one half inches, while Willemoes-Suhm mentions one "measuring nearly two feet across the legs." The remaining family, NYMPHONIDÆ, has the mandibles and palpi well developed.

On the systematic position of the Pycnogonida, anatomy and embryology throw but little light. Dr. Hoek says, "The Pycnogonida form a distinct and very natural group (class) of arthropodous animals. Their common progenitor (their typical form) must be considered as a hypothetical pycnogonid with three-jointed mandibles, multi-jointed palpi, and ovigerous legs with numerous rows of denticulate spines on the last joints." Of their relationships to the Crustacea or the Arachnida we know nothing.

TARDIGRADA.

The Water Bears derive their common name from a more or less fanciful resemblance to the true bears, most evident in side views,

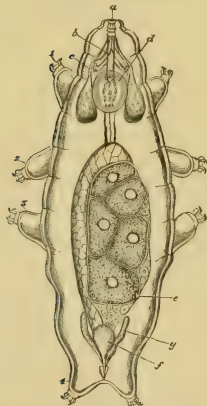


FIG. 110. — *Macrobiotus schultzei*, water-bear, enlarged 100 times. a. Mouth. b. Gullet. c. Salivary glands. d. Pharynx. e. Ovary. f. Vesicula seminalis. g. Testes. 1, 2, 3, 4. Legs.

while the scientific name of the group has reference to their slow progression. The Tardigrada are microscopic forms which are occasionally found in moist sand and moss, and but rarely free in the water. The body is elongated, and indistinctly shows signs of segmentation. Like the sea-spiders which we have just passed, they have four pairs of limbs, each terminated by two or more claws. The mouth is at the anterior end of the body, and is armed with organs which closely resemble those of some of the true mites to be described farther on. A little distance behind the mouth occurs the muscular pharynx, and from this the alimentary tract, widening out in the middle to a considerable extent and then contracting, pursues a straight course to the anus at the posterior end of the body. No respiratory or circulatory apparatus exists. The nervous system is of the usual arthropodal character, and consists of a supra-oesophageal ganglion or brain, and a ventral chain of four large paired ganglia corresponding to the limbs. Occasionally a couple of simple eyes are connected with the brain. The water-bears are hermaphroditic, both the male and female organs being present in the same individual and opening together into a cloaca.

The little that is known about the embryology of the group does not throw any light on their systematic position, but the facts that are known of their anatomy would seem to indicate that the position of these forms may be near the lower mites (Acarina). The eggs are very large, and when they are laid the parent casts its integument, which covers them in a manner somewhat like that of the ephippia of the Entomostraca described on a preceding page. The egg undergoes total segmentation, and the young hatch with four, or occasionally three, pairs of appendages.

The water-bears are not very common, but should be looked for in water squeezed from the damp moss of swamps. Like the rotifers which occur with them they are said to withstand desiccation, the addition of water to their dried bodies reviving them. There are several genera, *Macrobiotus*, *Milnesium*, and *Echiniscus* being the most prominent. No fossil forms are known.

SUB-CLASS. — GIGANTOSTRACA.

Only one living genus remains to illustrate this group which once formed a very prominent feature in the fauna of the world. Naturalists are now pretty well agreed in the union of the trilobites, horseshoe crabs, etc., in a group to which Professors Haeckel and Dohrn have applied the name Gigantostraca, and Dr. Packard the name Paleocarida. To the latter student belongs the credit of first clearly showing the close relationships existing between the Trilobita and Merostomata. Of the extinct forms of course but little can be known. Geologists can learn but little of the anatomy or embryology of the fossil forms, and hence we must depend largely upon analogies drawn from the study of *Limulus* for our knowledge of the trilobites.

ORDER I. — TRILOBITA.

There are but few groups of fossil animals which possess more popular interest than those peculiar forms known as trilobites. This arises not only from the beauty of their form, but from the questions which have arisen in regard to the position which they should occupy in the systems of classification. Linnaeus described the few which were known to him as *Entomolithus paradoxus*, thus clearly indicating his belief, that they were fossil articulates. Latreille, struck by their superficial resemblance to the chitons, thought to range them near those forms among the Mollusca. Usually, however, they have been regarded as Crustacea, and have been assigned varying positions within that group, some considering them as allied to the Phyllopoda, while others placed them near the isopodan genus, *Serolis*. More recently they have been considered as near relatives of the horseshoe-crab, and together with that problematical form they have been shifted about, at one time being regarded as Crustacea, at another as Arachnida, or as occupying a place between these two groups.

This uncertainty has arisen partly from the fact that we know almost nothing of the structure of the trilobites, and until recently but little of the anatomy of *Limulus*, and less of its development.

The name Trilobite, which means three-lobed, is applied to certain articulated animals, in which the body is usually divided into three well-marked regions: first, a head, rounded in front and usually bearing large compound eyes; second, a thorax made

up of a varying number of nearly similar segments, and lastly an abdomen, or as it is called in technical works, a pygidium, composed of a number of segments united together. Until very recently nothing has been known of the nature of the under-surface, or the character of the limbs of the trilobites. The first specimen, showing the under-surface of a trilobite, was described by Mr. Billings, but, as the appendages were rather indistinct, the evidence was not accepted by all. Mr. Walcott then investigated the subject by means of sections of the fossils, arriving at many satisfactory results, but leaving many other problems still unsettled. Lastly, Professor Mickelborough described another specimen, showing the limbs, but without throwing any new light on the subject.



FIG. 111. — *Triarthrus becki*, trilobite, natural size.

The head is rounded in front, and frequently its posterior angles are produced into spines, which sometimes exceed the body in length. The central portion of the head is raised above the rest and constitutes the glabella. On either side of the glabella are the eyes, when these organs are present. These eyes are either composed of isolated ocelli, or groups of ocelli, or lastly, compound eyes similar to those of other arthropods, and which, if we may accept the sections of Mr. Walcott, as interpreted by Professor Packard, are essentially similar to those of *Limulus* as far as the hard parts are concerned. On the under-surface of the head is a shield-shaped upper lip, behind which is the mouth. Of the other organs of manducation nothing certain is known. The thorax is divided into three longitudinal portions by two furrows. The medium ridge is known as the axis, the lateral portions as the pleurae. The joints of the thorax, in many forms, were freely movable on each other, and some of these animals possessed the power of rolling themselves into a ball just as does the familiar pill-bug of to-day, and fossils in this condition are frequently found. On the under-surface of the thorax occur the several jointed limbs, one pair to each segment. Attached to the basal joint of each leg is a peculiar organ, curled in a spiral, which Mr. Walcott interprets as a gill.

The abdomen is divided in the same manner as the thorax, the axis being continued to the end of the body. Beneath the abdomen, Professor Mickelborough thinks that he has found lamellar appendages like the gills of *Limulus*; but Mr. Walcott, in his restoration, continues the ambulatory legs into this region.

The development of the trilobites has been studied by Barande in Europe, and by Walcott in our own country. In the earliest known stages the body is a small, oval disc, without any distinct segmentation, but with growth, segments appear, their number increasing with age. There is no metamorphosis, the development being direct. The head of the adult can be resolved into six segments; the thorax contained from two to twenty-six, while the abdomen was composed of, at the most, twenty-eight segments.



FIG. 113. — Larva of *Sao hirsutus*, natural size and enlarged.



FIG. 112. — Larva of trilobite, *Trinucleus ornatus*, natural size and enlarged.

The trilobites made their appearance in the lowest Silurian, and died out at the close of the carboniferous. Both in number of

individuals, and in variety of forms, the order attained its highest point in the upper Silurian. About four hundred species distributed among fifty genera have been described.

Of their habits nothing definite is known. Dr. Burmeister thought that they lived in large schools in the shallow water along the shores, swimming back downwards like so many Phyllopoda to-day. Dr. Packard, on the other hand, thinks that, like the living horseshoe crab, they burrowed just beneath the surface of the mud and sand at the bottom of shallow waters,—a view which we are inclined to consider most probable.

ORDER II.—MEROSTOMATA.

The genus *Limulus*, which embraces the forms familiarly known as horseshoe crabs, king-crabs, and Molucca-crabs, is the only living representative of the group Gigantostraca. The living species have a peculiar distribution. On our own coast *Limulus polyphemus* extends from Maine to Florida and the West Indies, while *L. moluccanus* and *rotundicaudus* and two other doubtful species are found on the eastern shores of Asia. No examples are found on the western shores of either continent, and none have been reported from South America.

The horseshoe is composed of three portions movably articulated to each other. The anterior, the cephalothorax, closely resembles in outline the foot of a horse, and gives the common name to these animals. Behind this comes a wedge-shaped abdomen, and then a long, bayonet-shaped caudal spine. On the upper surface of the cephalothorax are the eyes. Of these two are compound, one on either side of the body, while near the front margin in the median line a couple of simple eyes occur. The lower surface of the cephalothorax closely follows the upper, so that instead of the thick body which would be expected from seeing the vaulted back, the body is really very thin. Near the centre of the lower surface arise six pairs of legs, and between the second pair is the mouth. The first pair are small, and differ considerably in the two sexes; in the female they end in a regular pincer, but in the male the finger is bent and folds over the thumb. The next four pairs of feet may either terminate in a pincer, or one or more may end in a simple

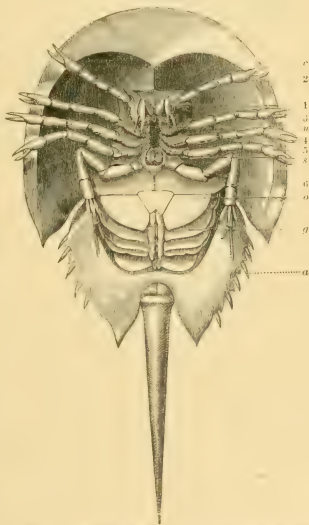


FIG. 114. — Under-surface of horseshoe crab, *Limulus polyphemus*. a, Abdomen. c, Cephalothorax. g, The first gill-bearing abdominal appendage. m, Mouth. o, Operculum. s, Metastoma. 1 to 6, Cephalothoracic limbs.

claw, there being a difference in the different species and sexes. The sixth pair, however, terminates in two flat spines, and just above these on either foot is a whorl of similar plates. These are of great use to the animal in walking, as they give a firm foothold in the soft mud and sand. Between the bases of the sixth pairs of feet is the metastoma, a pair of single-jointed appendages.

The abdomen above shows indistinct traces of its original segments, while its lateral margins are armed with movable spines. Beneath are found the gills. These are composed of numbers of thin plates, arranged like the leaves of a book, and supported on five pairs of greatly modified limbs, the whole being covered by the anterior pair of abdominal appendages which form the operculum.

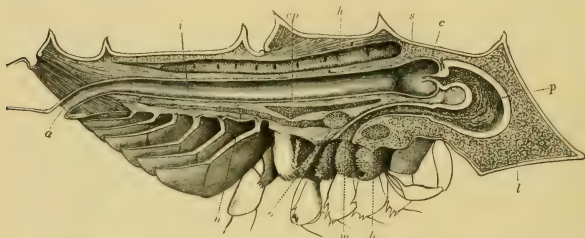


FIG. 115. — Longitudinal section of *Limulus*. *a*, Anus. *b*, Brain. *c*, Cone. *cp*, Cartilaginous plate. *h*, Heart. *i*, Intestine. *l*, Liver. *m*, Mouth. *n*, Nervous cord. *o*, Oesophageal ring. *p*, Proventriculus. *s*, Stomach.

From the mouth the alimentary canal first goes forward, widening out into a crop or proventriculus, the walls of which are lined with chitinous folds. This crop bends on itself and communicates by a small tube with the intestine, which pursues a straight course to the end of the abdomen. The liver and genital organs occupy the greater part of the body. The heart is an elongate organ, and the nervous system consists of a ring around the oesophagus, from which arise the nerves supplying the cephalothoracic members, and a long cord which gives off nerves to the gills, etc. One remarkable peculiarity should be mentioned here: The oesophageal ring and the nervous cord are ensheathed in the ventral arteries so that they are bathed with the blood.



FIG. 116. — Early stage of *Limulus* embryo.

It is extremely probable that the same individuals deposit their eggs more than once each year, the favorite time being at the time of the full moon, when the tides run unusually high. The eggs and milt are placed in hollows near high-water mark, and are covered with sand by the retreating tide. The time of spawning is in the months of May, June, July, August, and probably in the Southern States, March and April. The eggs are small, resembling in appearance seed-pearls, and are not easily distinguished from the sand in which they are deposited. Of the early stages of development nothing certain is yet known. By some process the eggs become enveloped at an early day with a cellular membrane, and subsequently the six pairs of cephalothoracic limbs appear simultaneously. Next, the body segments

and the first two pair of abdominal limbs appear as flattened plates, resembling in appearance the same appendages in the adult. Soon the cephalothorax and abdomen become separated from each other, the limbs acquire more of the adult character, and the abdomen becomes segmented, while the jointing of the anterior part of the body disappears. At about this time the egg absorbs a quantity of water, and by the pressure the egg-shell is ruptured, but the embryo still remains within the cellular membrane. It now shows the first movements but in a very slight degree. The body is still enclosed in the first larval skin, but within this the spines of the sides of the abdomen and the hairs of the gills are seen to develop gradually, pushing off the old integument, although it does not really cast the skin until it hatches or leaves the cellular membrane in which it is enveloped. On leaving the egg the young *Limulus* bears a very close resemblance to the young trilobite, as can be seen by a comparison of figures 112 and 118. At this time the caudal spine has not been developed, existing only as an inconspicuous lobe at the extremity of the abdomen. The sutures of the abdomen have nearly disappeared. The young horseshoe swims freely, and with the first moult the caudal spine begins to assume the adult form.

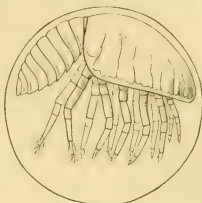


FIG. 117. — *Limulus* embryo, nearly ready to hatch.

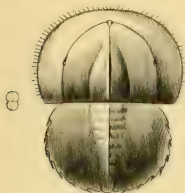


FIG. 118. — *Limulus*, just hatched, natural size and enlarged.

The question as to whether the horseshoe crab is a crustacean or an arachnid is too abstruse for consideration here. The chief advocate of the latter view is Professor E. Ray Lankester, and the arguments upon which he places the most dependence are the nature and homologies of the walking legs, and the origin of the nerves which supply them; the structure of the eye, and a more or less perfect homology existing between the gills of the horseshoe and the pulmonary lamellae of the scorpions, to which we shall refer in a subsequent portion of this volume. Additional evidence for this view is also found in the little which is known of the embryology. In the opinion of the writer enough has been discovered to show that *Limulus* is not a crustacean, but it has yet to be proved that it should be placed near the scorpions. The most important objection to such a course are the gills, which are fitted for aquatic respiration, and the absence of any trachea.

The horseshoe crab frequents sandy and muddy shores, and especially sheltered bays and estuaries where it is not exposed to the full force of the waves. It burrows just beneath the surface, a life for which its structure is eminently adapted. The sharp anterior edge of the thorax is peculiarly fitted for being forced through the sand, while the caudal spine, and especially the sixth pair of feet with their whorls of flat spines, afford a firm foothold for forcing the body forward. The crab first arches its body by bending it at the joint between the cephalothorax and abdomen, draws the sixth pair of legs forward, and then extends the body, pushing with all its might with the legs and tail. Occasionally it leaves its underground burrows and moves over the bottom, where its progression is a true walk, in which the last five pairs of legs are employed.

Limulus lives upon the many small animals which it finds in the mud, worms forming the bulk of its diet. It grasps the food by one or more of its numerous pincers, and places it between the spiny basal joints of the legs, which are kept in constant motion rasping the food into minute particles and forcing them into the mouth.

The horseshoe crab, like other Arthropoda, allows for increase in size by moulting. The hardened integument of the cephalothorax splits along the sharp margin, and through the opening thus afforded the animal extracts himself, leaving even the lining of the anterior and posterior portions of the digestive canal behind.

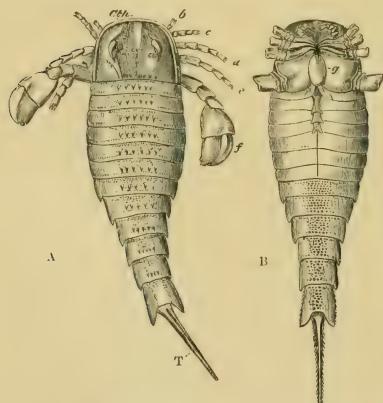
Like many other types of animals which have existed on the earth through many geological periods, the horseshoe crab has great vitality. Not only can it bear immersion in fresh water for several days, or even a complete removal from any aqueous element for the same length of time, but its eggs are laid in the sand, where they are twice a day left uncovered by the retreating tide, and are exposed to the fresh water of the frequent rains of spring.

SUB-ORDER I. — PÆCILOPODA.

Limulus and its nearest fossil allies are united into a sub-order under the above name. Of the living species of *Limulus* we have already spoken above. The genus makes its appearance in the lithographic slates of Solenhofen, Bavaria, which are of Jurassic age. *Prestrichia* and *Euproöps* are found in the carboniferous rocks of Illinois. In their general appearance they differ but little from the *Limulus* of to-day.

SUB-ORDER II. — EURYPTERIDA.

The animals which are associated together under the sub-ordinal name Eurypterida



appear in the upper Silurian, and become extinct in the carboniferous. In general appearance they are intermediate between the king-crab and the scorpions. To the anterior portion of the body, which we may call the cephalothorax, are attached at the most but five pairs of limbs which, like those of *Limulus*, have spines on the basal joints. One or more of the anterior pairs may terminate in a pincer, while the posterior pair are usually expanded so as to form a broad paddle. A metastoma is present, occupying the same place as that of *Limulus*. On the upper surface are the two eyes. The abdomen is large and long, and is composed of twelve or more free segments, and

FIG. 119. — *Eurypterus remipes*, reduced. A, dorsal, and B, ventral view. a. Eyes. b, c, d, e, f. Legs. g. Metastoma. eth. Cephalothorax. T. Telson.

terminated by a bayonet-shaped or spoon-shaped caudal spine. No abdominal limbs are present. *Eurypterus remipes*, the typical species, is common to the Silurian rocks of Europe and America. *Eusarcus scorpionis* occurs in the water-lime group of Buffalo, N. Y. *Pterygotus* is another prominent genus. It is supposed that the Eurypterida swam near the surface, and were more predatory animals than the king-crabs.

In the lower carboniferous rocks of Great Britain and the continent a number of small fossils have been found, the systematic position of which is extremely doubtful. From their approximately circular outline they have received the generic name *Cyclus*. In length they average between a quarter and a third of an inch. Dr. de Koninck would consider them as most nearly related to the trilobites, while Dr. Woodward, the able paleontologist of the British Museum, thinks that they may be "the larval stages of *Prestwichia*, *Belinurus*, etc., the ante-types in carboniferous times of the modern king-crab."



FIG. 120. — *Cyclus jonesianus*, enlarged.

PENTASTOMIDA.

In the Pentastomida, for which no common name exists, we have a type so modified by a parasitic life that it is difficult to trace at first sight even arthropodan characters, much less features by which it can be assigned to any of the well-defined groups, although it seems probable that, like the Tardigrada, it belongs near the mites. The body is long and worm-like, and is constricted by numerous thickenings of the body-wall, so that it appears as if made up of many short segments. The mouth occurs near the anterior end of the body, and on either side of it are two very minute curved hooks, and in front of them a pair of rudimentary palpiform organs. These hooks can be drawn into small openings, and as these with the mouth are five in number, the applicability of the name (five mouths) is evident. Each of these hooks is solid, and is moved by appropriate muscles inside of the body. Another name, *Linguatulina* (little tongue), has been given to these forms.



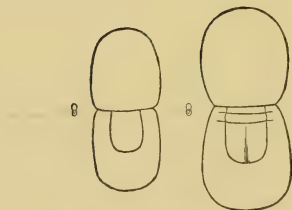
FIG. 121. — *Linguatula diesingii*, enlarged four times.

From the mouth the alimentary tract pursues a nearly straight course the whole length of the body, being held in place by a membrane similar to the mesentery of the vertebrates. The nervous system consists of a ring around the œsophagus, with a posterior enlargement, from which nerves are given off to the different portions of the body. The sexes are distinct, the males being usually much smaller than the females. The eggs undergo their development in the ovary, and the larvae resemble, in general appearance, both the young of the mites and of some of the parasitic Crustacea.

The habits of these forms are more interesting than is their structure, and in this respect they show a great resemblance to the cestoid worms, of which an account is given in the first volume of this series. In their sexless condition they are found in the lungs and liver of various rodents and herbivorous mammals, and also of some of the reptiles. Leuckart has traced out the life-history of some of the forms with great care. When the flesh of the hare or rabbit containing these forms is consumed

by a dog, wolf, or other carnivore, these sexless forms pass to the nasal region, and there gradually acquire the sexual condition, develop their young, which pass out with the nasal mucus, and fall upon the grass, or other food of the rodents. These young may then be eaten by the rabbit, and in his body they develop by a series of changes, pass through the walls of the intestine to the lungs or liver, where they become encysted, ready to go through the same cycle of changes as did their parents. Thus, like the tape-worms, two distinct hosts are necessary to complete the circle of life. Other forms occur in serpents, apes, etc., and even in man, but their life-history has not been traced with the completeness of that of *Pentastomum tænioides* detailed above.

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FIGS. 122 and 123. — *Agnostus nudus*, trilobite, larva and adult.

CLASS II. — INSECTA.

THE term *Insecta* is used with varying significations by different authors, some restricting it to the six-footed forms, while others enlarge it so as to include the spiders, mites, and millepeds as well, reserving the term *Hexapoda* for the *Insecta* of the former.

In the present work the term is used in its most comprehensive form, and includes all arthropods in which the body is more or less clearly divided into three regions, — head, thorax, and abdomen; which respire by trachea instead of gills; undergo a more or less complete metamorphosis in passing from the embryonic to the adult condition; and which have, at no stage of development, the two-branched appendages which we have found so common among the *Crustacea*.

The variety of forms contained in the *Insecta* is so great that only the most general statements can be made regarding the class as a whole, and the more special characters are hence reserved for mention under the different divisions.

The body of insects, like that of all arthropods, is made up of a series of segments ranged one after another, forming a body of varying length. The number of these segments varies greatly, there being, for instance, ten in some *Myriapoda*, and two hundred in others of the same group. Each of these segments (and the same is also true of *Crustacea*) is regarded as made up of eight portions, the relations of which may be seen in the accompanying diagram. Of these segmental elements the two upper are the terga (singular tergum), the upper lateral ones are called epimera, the lower lateral episterna, while those on the ventral surface are known as the sterna. These elements are variously developed in the different forms. Between the sterna and the episterna arise the legs and their various modifications, which, as has just been said, are composed of but a single series of joints, and never present a two-branched condition in either embryo, larva, or adult. Between the episterna and the epimera are the openings to the respiratory system, a feature which is entirely confined to the group now under discussion. In the six-footed forms there are additional locomotive organs, the wings, never more than two pairs, and these when present are inserted between the epimera and the terga.

The body of insects is usually divisible into regions or groups of segments. In the typical six-footed forms we have three of these divisions known as head, thorax, and abdomen. In the spiders the head and thorax are more or less completely united into a cephalothorax, while the abdomen remains distinct. In the myriapods the head is well distinguished, but the remaining segments are so similar that no differentiation

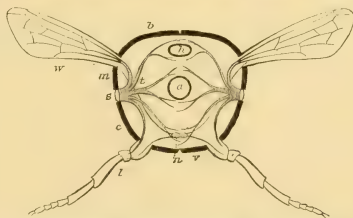


FIG. 124. — Section through the thorax of an insect. *a*, Alimentary canal. *b*, Tergum. *c*, Episternum. *h*, Heart. *l*, Leg. *m*, Epimerum. *n*, Nervous cord. *s*, Spinacle. *t*, Trachea. *v*, Sternum. *w*, Wing.

into thorax and abdomen exists. Lastly, in the mites all of the regions are more or less confused and merged into each other.

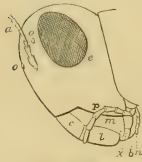


FIG. 125. — Head of grasshopper. *a*. Antenna. *b*. Labium. *c*. Clypeus. *e*. Eye. *l*. Labrum. *m*. Mandible. *n*. Labial palpus. *o*. Ocelli. *p*. Maxillary palpus. *x*. Maxilla.

The number of segments which enter into the composition of the head is variously stated, some authors admitting only two, while others strive to recognize seven. It would, however, seem that there are in reality four cephalic segments, — a view which receives confirmation, according to Savigny's law, in the number of appendages in this region, which are also four. These appendages are a pair of antennæ and three pairs (mandibles, maxillæ, and labium) concerned in the preparation of food for the mouth. In the simpler types of insects (as the grasshopper) these mouth-parts acquire their typical development; in others (as the fly and butterfly) they become greatly modified, so that the study of their relations becomes a matter of some difficulty. In the spiders, if we regard all four of the walking feet as thoracic, there are but two pairs of appendages

which can be regarded as belonging to the head, — the chelicerae, or mandibles, and the palpi, or pedipalpi.

The head also bears the eyes. In the spiders and most myriapods only simple eyes or ocelli are found; but in most hexapods we have a pair of compound eyes, and usually, except in most beetles, two or three ocelli in addition are present. The antennæ may with great probability be also regarded as sense organs, — authors interpreting the minute structures found upon them as either olfactory, auditory, or tactile organs.

The thorax, which exists as a distinct region only in the Hexapoda, is there composed of three segments, each of which bears a pair of limbs fitted for locomotion (making six legs in all), and in addition each of the two hinder segments usually supports a pair of wings. These thoracic rings have their distinctive names; the first being the prothorax, the middle one the mesothorax, and the hinder one the metathorax.

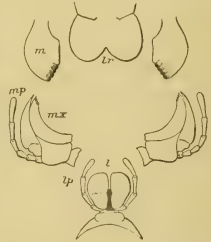


FIG. 126. — Mouth-parts of grasshopper. *l*. Labium. *lp*. Labial palpus. *lr*. Labrum. *m*. Mandible. *mp*. Maxillary palpus. *mx*. Maxilla.

Each thoracic leg is made up of a series of joints, and as each of these has a technical name of frequent use in all descriptive works, and, from necessity, in the following pages as well, we insert them here. The first joint, the one which articulates with the body, is called the coxa; next comes another small joint, the trochanter; the thigh or femur, a long and stout portion, is third; the shank or tibia, also long but more slender, comes next; and, lastly, we have the tarsus or foot, which is made up of a number of small joints arranged one after the other like the joints of the human finger. The number of these tarsal joints varies considerably, but the typical number in most hexapods is five.

In the adult insects the appendages of the abdomen are used in locomotion only in the myriapods. In the other groups, when present, they are much altered in form, and



FIG. 127. — Typical insect leg. *c*. Coxa. *f*. Femur. *o*. Trochanter. *t*. Tarsus. *t*. Tibia.

adapted for varying purposes. Thus in the spiders, the spinnerets, and in the true insects, the ovipositor or sting has been shown to be in reality composed of modified appendages homologous with those on the other segments of the body. These greatly-modified abdominal legs do not occur on all the segments of the adult, but in the larval stages most insects have these appendages developed to a greater or less extent, and frequently of use in locomotion. Even here frequently some of the segments are without well-marked limbs. The discussion of these changes produced by metamorphosis will be resumed when treating of the sub-classes and orders.

The nervous system of insects is constructed upon the same plan which, in the preceding pages, we have found to be common to all Arthropoda. There is an enlargement in front of the œsophagus, the so-called brain, which is connected with a longer or shorter chain of ventral ganglia, or nervous centres, behind that tube. In *Peripatus* this ventral chain consists of two widely-separated nervous cords connected by numerous fine filaments, and as the main cords are without well-marked enlargements or ganglia the ventral chain closely resembles a ladder. In the myriapods the nervous system most closely approaches what is considered as the typical condition, there being

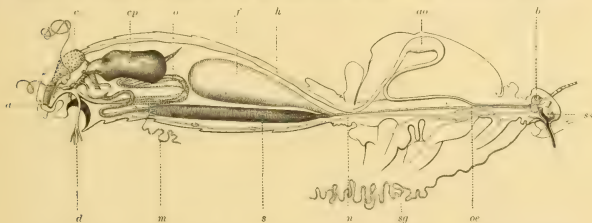


FIG. 128.—Anatomy of a butterfly. *a*, Anus. *ao*, Aorta. *b*, Brain. *c*, Colon. *cp*, Copulatory pouch. *d*, Oviduct. *f*, Food reservoir. *h*, Heart. *m*, Malpighian vessels. *n*, Nervous cord. *o*, Ovary. *oe*, Œsophagus. *s*, Stomach. *sg*, Salivary gland. *ss*, Sucking stomach.

a compound ganglion in each of the segments of the body. In the six-footed insects the ventral chain is usually abbreviated to a certain extent by a fusion of some of the ganglia; and in the Arachnida this reduction is frequently carried out to the greatest degree, there being in some forms but a single compound ganglion behind the œsophagus, while in others the brain almost entirely disappears.

Besides the nervous system thus briefly described, there are two other portions well developed. One of these supplies the alimentary tract, and is called the sympathetic from its analogy with a system in the human body with a similar distribution and the same name. The other is distributed to the respiratory organs, giving off branches to the spiracles and trachea.

The digestive canal of insects, like that of all animals above the Cœlenterata, is divided into three regions; the middle portion being formed from the primitive embryonic stomach, while the anterior and posterior portions are produced by the subsequent pushing in or invagination of portions of the outer embryonic layer until they meet and join the middle portion (see fig. 11). A distinction is however to be noticed here between the insects and the crustaceans, as in the latter the primitive stomach is produced by a true invagination, a regular gastrula being produced, while

in the insects there is no true gastrula, the primitive stomach always being formed in the yolk. The anterior and posterior divisions are lined with a hardened chitinous layer, while the median portion has no such lining. The anterior portion, the function of which is the preparation of the food and its introduction into the stomach, is usually a simple tube or œsophagus, but frequently it is divided into several portions, with other functions. In some forms, as the moths and butterflies, there is a "sucking stomach" in the head which acts as a pump, drawing the fluids into the mouth and forcing them back to the true stomach. Others, as the crickets, have an enlargement farther back (the crop) lined with chitinous teeth, the object of which is to still further comminute the solid food upon which these forms live. The proventriculus or gizzard is another enlargement of the anterior portion found in most insects.

The stomach proper is either a simple tube or it may have pocket-like prolongations which greatly increase its digestive surface. These pockets are especially noticeable in some of the flies, the grasshoppers, and especially in the spiders. Digestion is accomplished by the passage of the nutritive portions through the walls of the stomach, when they enter into the general circulation without the intervention of a system of lacteals like those found in the human body. It is a peculiar feature that in the young of some of the bees and wasps and flies the stomach ends blindly, there being no connection between that organ and the intestine, though in later life the connection is made.

The hinder portion of the alimentary canal, the intestine, is usually short. Into it open numerous tubes, the so-called Malpighian vessels, the function of which is the same as the kidneys of the higher forms. These urinary tubules are found only in insects. A still further feature or accessory of the digestive canal are the salivary glands, which pour their secretion into the mouth. These organs are present in almost every member of the group, and, on the contrary, are entirely absent in the Crustacea. Usually there is but a single pair of salivary glands, but this number may be increased, there being not unfrequently two, and even three pairs of these organs.

The heart of insects may be said to resemble in a general way that of most Crustacea. As in that group, it is a long, many-chambered organ lying above the intestine. It forces the blood forward through an aorta of varying length, which runs from the anterior end of the heart to the vicinity of the brain. In returning to the heart the blood collects in two venous trunks, by which it is brought to the posterior portion of the central organ. Finer subdivisions of the arterial and venous systems are absent, and during a portion of its course the blood flows in open spaces between the muscles and viscera.

In the phenomena of respiration, and the organs concerned therein, insects present one of the greatest differences from the Crustacea. In the latter group, as we have seen, organs of respiration, when present, take the form of gills, borne on some of the feet, and the blood in passing through them is brought in contact with the oxygen dissolved in the water. Insects, on the other hand, are fitted for breathing air by means of tubes or trachea which penetrate to all parts of the body, and which give the name, synonymous with *Insecta* as here used, of *Tracheata* to the group. In the thoracic and abdominal regions of the body there occur small openings on the sides, never more than one on a side in each segment, which are known as spiracles or stigmata. It is through these, and not through the mouth, that an insect breathes. In some larvæ there are eleven pairs of these spiracles, while in the adults the number is frequently much less. In most hexapods there are but nine pairs.

Each spiracle consists of a horny ring placed, as we have seen, between the epimera and episterna of a segment. The opening is provided with a pair of valves by which it may be closed, and besides there is frequently a strainer of fine hairs and interlacing meshes, the object of which is to prevent foreign particles from entering the air tubes.

The air tubes, or trachea, are minute branching canals, arising from the inside of the spiracles, by which the air necessary for respiration is conveyed to all parts of the body. They are composed of three layers, the middle of which only possesses any popular interest. This is composed of a filament wound in a spiral between the other two, giving the trachea the spiral character so often seen in microscopic preparations. In many cases branches of the tracheæ unite to form a continuous air tube along each side of the body, and oftentimes large cavities or air sacs are formed in various portions of the body. These, when filled with air, tend to reduce the specific gravity of the insect, and hence may play an important part in flight. In *Peripatus* the tracheal tubes are irregularly distributed over the inner surface of the body cavity, the anterior and posterior portions of the alimentary canal and the oviduct; in most other forms the branches are regularly arranged, and have a more extensive distribution.



FIG. 129. — Trachea of an insect.

In the aquatic larvæ of many insects there are no stigmata, and to replace these openings, gills are introduced, usually on the abdomen. These gills, the purpose of which is to extract oxygen from the water, differ materially from those of crustaceans, for they are penetrated by tracheæ instead of blood-vessels, and these air tubes convey the oxygen to other portions of the tracheal system. With the development these gills are almost invariably lost, the stigmata appear, and a connection is established between them and the system of air tubes.

In the spiders an additional feature appears, the existence of so-called lungs. These are formed by a trachea which arises from a spiracle in the ordinary manner. It then breaks up into a number of small flattened branches or plates, which are arranged like the leaves of a book. These are the organs to which Professor Lankester, as mentioned on a preceding page, would compare the gills of a horseshoe crab. There may be one, two, or four pairs of these lungs or pulmonary organs, which are only found in the abdomen.

In some of the insects, as the lower mites, and the "spring tails" (*Collembola*) the tracheal system has entirely disappeared, and respiration is carried on through the general integument of the body.

The act of breathing can be easily witnessed in the larger insects, especially in those which, like the grasshopper or hornet, have the abdomen naked and not covered with the wings or hairs. Holding one of these insects with the fingers or with a pair of forceps, the abdomen will be seen to elongate and contract with great regularity. Each time it elongates air is drawn in through the spiracles, while the contraction, by lessening the capacity of the body, forces out the air which has been used in aerating

the blood. Here, as in the higher vertebrates, respiration raises the temperature of the body, and for the same reason. We have the authority of both Huber and Newport for the fact that humble-bees when incubating pupæ raise the temperature by increasing the number of respirations.

We can best discuss the question of the development of insects, and especially the metamorphoses, in connection with the various groups, there being such differences that a general account which attempted to take cognizance of all would be very confusing. There are, however, several features which are common to all which may be mentioned here, especially since they serve to make more evident the great differences existing between the Crustacea and the Insecta.

The segmentation of the egg is usually superficial, the central portion not dividing at first. From this central yolk arises the primitive stomach of the embryo,—a marked difference from the way in which the same portion is formed in the crustaceans, where, as we have seen, there is a true invagination. At an early stage the eggs of most insects become enveloped in a cellular membrane, which, from being formed in a strikingly similar method to that in which one of the fetal membranes of the higher vertebrates arises, has been called the amnion. The appendages grow in much the same way as in the group just passed, but it is to be noticed that in no stage of the development of the insects do we find a two-branched appendage, a feature so common among the crustaceans. The middle germinal layer (mesoblast) also arises in very distinct ways in the two groups.

There is no group of animals upon which more has been written than upon the insects. Ever since naturalists began the study of nature these forms have attracted especial attention. From every point of view they possess interest. Their shapes and colors make them attractive to lovers of the beautiful and the grotesque; their habits are interesting, and their metamorphoses are marvellous. There is a far more practical side to their study. A large number are of economic importance. Some few are of direct value to man: from the silk-worm we obtain one of the most valuable textile materials, from the cochineal insect one of our most brilliant dyes. In another very important manner insects play a part in matters which affect human interests. It is now, thanks to the labors of Darwin and Hermann Müller, a well-known fact that a large proportion of the flowering-plants are incapable of self-fertilization, and were not pollen brought to the stigma from another flower of the same species no seeds would be produced. This fertilization is effected to a certain extent by the winds and other agencies of like character, but it is to the insects that we must turn for the most effective work in this line. These in their search for honey visit plant after plant, and from one they carry the pollen which becomes entangled upon their legs or bodies, and in such a position that in the next flower visited it will be brought in contact with the stigma, and fertilization will thus be effected. It has been clearly shown that for this purpose there exist many mutual adaptations,—there being many insects which can fertilize only one species of plant, and, conversely, many flowers which require the presence of a peculiar insect to carry the pollen from the stamens to the pistil. The subject is a large one, and we can but touch it in this brief manner; but those who wish to study it further will find ample material in the writings of Darwin, Müller, and Trelease, and better, in the relations of the animals and plants around them.

Still other insects are of value to man from their carnivorous habits. Some of these dispose of large amounts of refuse matter which would otherwise decay, producing

disagreeable or unhealthy products. Others by feeding on insects reduce the number of the forms which injure the crop.

In their injurious aspects the insects have possibly attracted the most attention, and long statistical tables are frequently published showing the value, in dollars and cents, of the human possessions destroyed by these apparently insignificant forms. In the following pages especial attention will be paid to these noxious insects, and we have here only to instance the grasshopper-plague of Kansas and Nebraska, the damage produced by the Hessian-fly, the onion-fly, and the chinch-bug, and the ravages of the clothes-moth and the carpet-beetle, to call to mind this important aspect of the group.

In number of species, as well as of individuals, the group Insecta is by far the largest of the divisions of the animal kingdom. It is estimated that from a quarter to half a million distinct forms exist on the face of the globe. These are divided as follows: Myriapoda, 1,000; Arachnida, 5,000; Neuroptera, 7,000; Orthoptera, 7,000; Hemiptera, 10,000; Coleoptera, 125,000; Diptera, 30,000; Lepidoptera, 25,000; Hymenoptera, 25,000. Of course these numbers are merely guesses; but when we consider that nearly 100,000 species of beetles are catalogued as being in the various collections of the world, we see that these estimates are probably within limits. The number of individuals is, of course, beyond any possibility of estimation.

For our purposes we may divide the class of Insecta into four sub-classes:—Protracheata, embracing the single genus *Peripatus*; Arachnida, Myriapoda, and Hexapoda, or insects proper.

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FIG. 130. — Larva showing abdominal legs.

SUB-CLASS I.—MALACOPODA.

To this division of insects (for which the name *Protracheata* has also been proposed) belongs the single genus *Peripatus*. In the early part of the present century the Rev. Lansdown Guilding described the first species, from the West Indies, under the name *Peripatus iuliformis*, the specific name alluding to its general resemblance to the galley worms. Other forms have since been described from South America, New Zealand, and the Cape of Good Hope. Mr. Guilding was under the impression that this form belonged to the molluscs; but subsequent students assigned it a place among the worms, through its affinities to the insects, and especially to the myriapods, were hinted at. In 1874 Mr. Moseley, one of the naturalists of the "Challenger" expedition, described the anatomy of the species occurring at the Cape of Good Hope, and set at rest all questions regarding the systematic position of *Peripatus*.

Peripatus is strikingly like a myriapod in general appearance. It has a long body, which is supported on numerous legs, varying in number from seventeen and nineteen to thirty and thirty-three in the different species. The head bears a pair of ringed antennæ, and at their bases are a pair of simple eyes. On the lower surface of the head is the mouth, armed with two pairs of laterally moving jaws, and at each side of the mouth is a small papilla, at the summit of which a slime gland opens.

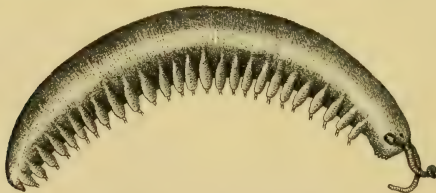


FIG. 131. — *Peripatus*, enlarged three times.

The alimentary canal is nearly straight, and is composed of a narrow œsophagus and intestine, and a broader stomach. A pair of salivary glands are also present. The heart is a simple tube, and is but little specialized. The nervous system has already been referred to.

The most interesting anatomical feature is the respiratory apparatus. Scattered over the surface of the body are the spiracles, but in certain regions, as between the bases of the legs, they are most numerous. Each spiracle opens into a short tube, from which arises a bunch of fine tracheæ. These tracheæ but rarely branch, and have the spiral filament very imperfectly developed. The sexes are separate, and the young undergo a large part of their development within the mother. But little is as yet known concerning the embryology of this form, although the subject has been studied by such masters as Balfour, Moseley, and Sedgwick.

Peripatus is especially interesting from the fact that its structure, and especially that of its tracheae, and the little that is known of its development all point to it as the living representative of the ancestor of all insects, and as a connecting link between that group and the worms.

But little is known of the species of this genus, although four have been described. The best known form is *P. capensis*, and next comes *P. novaezelandia*, the habitats of each being indicated by the specific name. *Peripatus capensis* lives in damp situations, under decaying wood, etc., and when at rest coils itself in a spiral, like a milliped, with its head in the centre. When in motion it extends its body to about twice its length when at rest. It has a gait like that of a caterpillar, its short, stout legs holding the body free from the ground. When annoyed it ejects a quantity of slime from peculiar glands within the body, the openings of which, as we have said, are on either side of the mouth. This slime is a very sticky and tenacious fluid, adhering very strongly to everything with which it comes in contact, and resembling bird-lime in its general characters. It, however, dries very rapidly.

The little that is now known concerning these very interesting forms will doubtless soon be greatly increased, for an English naturalist has just gone to the Cape to study their development, while two others are now at work at a monograph of the species.

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FIG. 132. — Embryo of *Peripatus*.

SUB-CLASS II. — ARACHNIDA.

In this division are included the mites, scorpions, harvest-men, and spiders. These animals usually have the body divided into two regions, an anterior, cephalothorax, and a posterior, abdomen. In the mites, however, these distinctions become obliterated, and the boundaries between the regions are very indistinct. The cephalothorax bears four pairs of legs adapted for locomotion, and in front of these are two pairs of mouth-parts, the anterior pair being called chelicerae, or mandibles, the other the palpi, or maxillae. These pairs are both post-oral, and hence we see that the antennae are lacking in this group. The walking-legs are composed of a series of joints, usually seven in number; but in some, as in the harvest-men, the last, or tarsal joint, is broken up into a large series of articles, while in some mites the distinctions between the joints of the limbs are greatly obscured, if not wholly obliterated.

The organs of vision, when present, are always simple eyes, placed upon the dorsal surface or the sides of the cephalothorax, and varying in number from two to twelve; their number and arrangement affording characters which are largely used in separating the different forms. Compound eyes, like those found among hexapods and many Crustacea, are entirely lacking.

The abdomen is without appendages except in the spiders, where the spinnerets, which are frequently jointed, are homologous with the other limbs.

The alimentary canal is nearly straight. Rarely it is a simple tube, but in most forms there are a number of pockets arising from the stomach, thus increasing the digestive surface. In some of the mites these pockets, or cæca, are so numerous and so greatly developed as to remind one of the extensively ramified digestive tract of a planarian worm. In the true spiders these appendages of the stomach are seen in their simplest form, and will be referred to again in treating of the common garden-spider. In *Galeodes* the pockets are very long, extending for some distance into the legs, reminding one of a similar extension of the alimentary tract which is found in the Pycnogonids. A sucking stomach is also frequently found. Salivary glands are almost invariably present, while in the higher forms a well-developed liver pours its secretions into the intestine.

The circulatory organs in the higher groups consist of a chambered heart and several arteries, distributed to the various portions of the body. In the scorpions we find in addition a venous system, while in the lowest mites not only blood-vessels but even a heart is wanting; the blood, propelled by the movements of the body, flowing between the various muscles and viscera in the same way that it does in many of the lower Crustacea.

In many of the lower mites, most of which are extensively degraded by their parasitic habits, no traces of respiratory organs have yet been found, respiration being effected by the whole surface of the body. In all other forms organs for the aeration of the blood, in the shape of tracheæ or modified tracheæ, are always present. These tracheæ may be of the normal type or they may be modified so as to form the lungs which have already been mentioned, or both lungs and tracheæ may be present together. The number of pulmonary sacs varies from two in most spiders and the whip-scorpions, and four in the Mygalidæ, to eight in the scorpions.

The sexes are separate in the Arachnida, and may usually be distinguished by the modifications of the palpi, pincers, or some of the legs. Some, as the scorpions, are viviparous, but the majority do not hatch from the egg until after oviposition. The eggs may either be deserted by the parent or carried around with her. We shall refer to the development when treating of the different groups.

The Arachnida are usually divided into three orders: Acarina, Araneina, and Arthrogastra.

ORDER I. — ACARINA.

This, the lowest order of the Arachnida, embraces the forms familiarly known as mites and ticks. In these the hinder segments of the body are usually distinctly separated from each other, but there is no constriction marking the division of the body into cephalothorax and abdomen, such as is so evident in the true spiders. The mouth parts (upper lip, chelicerae, and palpi) are usually united to a greater or less extent, forming a sucking tube, which in some forms acquires a considerable development. Respiration is usually effected by tracheae, which commonly arise from two stigmata, but, as we have just said, sometimes all respiratory organs are entirely absent. With the exception of the Oribatidae, which bring forth living young, all are viviparous, and the young, when they leave the egg, almost invariably have three pairs of feet, resembling, in this respect, the hexapod insects. The fourth pair are added with growth.

The different forms present many differences in habits; many are parasites; some live in the water, both salt and fresh, some in the earth, while others pass the greater portion of their life parasitic upon animals or plants. Directly they enter but slightly into the affairs of man, but indirectly many of them play an important part in human interests, some destroying injurious insects, while others, on the other hand, attack many objects which are of use or value to mankind.

The Acarina are divided into seven families, but it must be borne in mind that at least the minor divisions cannot all be regarded as firmly established; for there exists among many members of the order a marked polymorphism, the same species, at different ages or under varying environment, assuming characters so different as to lead naturalists to assign the different forms to distinct genera, or in some cases even to different families, and the errors thus introduced have only been discovered after long and careful study of the life-history of the form in question. So far as is known, the mites first appear in the pliocene division of the tertiary age, specimens of *Hydrachna* and *Trombidium* being found in the amber of Pomerania.

The first family to be considered is the ACARIDÆ. These have a soft skin, the body oval or elongate, ocelli absent, and the feet frequently terminated with an adhesive vesicle. The chelicerae are chelate or needle-shaped. Though minute, these forms are by no means to be despised, as they all come under the head of noxious insects, and besides injuring and destroying many human products they even produce disease in mankind. Space will allow us to mention but a few prominent representatives of the family.

In 1841 Henle described a peculiar parasite found in the hair-follicles of the human body, and a little later Simon published a careful account of the same form. From this time to the present this form has attracted considerable attention, and has been described under five generic names, that of *Demodex* having priority. The number of species is uncertain, it not being known whether the forms found in different animals

are really distinct. *Demodex folliculorum*, which sometimes occurs in the hair-follicles and sebaceous glands of man, especially those around the nose, is a minute worm-like form, with four pairs of legs near the anterior end of the body. In the human subject it is comparatively harmless, but either this form or a closely allied species is sometimes very injurious to hides. Dr. Faxon records a case where numerous cowhides, from Illinois and Wisconsin, were seriously damaged by this parasite; in some of the samples as many as eight or ten pits, some of which penetrated nearly through the skin, were found within the area of one square inch. Each of these pits was filled with a fatty substance containing multitudes of individuals. Similar injury to the skins of hogs has also been reported. But little is known concerning the development of these forms, some authors thinking them oviparous, while others think that the young are born alive. The larvæ, like those of most mites, have but three pairs of limbs.



FIG. 133. — *Demodex folliculorum*, follicle-mite, greatly enlarged.

The members of the genus *Sarcoptes* are very minute. They have a round or oval body, very short three-jointed legs, the two first pairs terminating in a sucking disc, while in the male the posterior pairs terminate in the same manner, but in the female these end in a long bristle. Several species have been described inhabiting various animals but the most prominent is the *S. scabiei*, the Itch-mite, which produces this disgusting disease in unclean people. The connection between the mite and disease was first pointed out by Avenzoar, an Arabian physician, in the twelfth century. These forms burrow just beneath the skin, especially in such protected parts as those between the fingers, the inside of the wrist, etc. The female is much the larger, attaining a length of about a sixtieth of an inch. The usual remedy is sulphur ointment rubbed into the skin. *S. canis* produces the mange in dogs, while other species are found in horses, cattle, sheep, etc. These latter are sometimes referred to a genus *Dermatodectes*.



FIG. 134. — *Sarcoptes scabiei*, itch-mite, greatly enlarged.

Among the more typical forms are the genera *Tyroglyphus* and *Typhlodromus*. In these the feet are long, four-jointed,

and terminate with a sucking disc, and the mandibles are scissor-like. The cheese mite, *Tyroglyphus siro*, is a familiar example, and scarcely less so is the flour mite, *T. farinæ*. Another species, *T. sacchari*, is frequently abundant in soft unrefined sugar, but it is rarely, if ever, found in refined sugar, which is apparently too hard for its existence. This form is supposed to cause the grocers' itch. One species is of benefit to man; *T. phyllozere*, as its name indicates, feeds on the *Phylloxera*, so injurious to the grapevines. Under certain conditions some of the species of *Tyroglyphus* assume a different form. A hard, brown chitinous covering develops within the skin, and then the latter cracks and the new form (originally described as *Hypopus*) emerges.

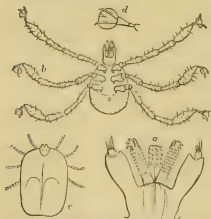


FIG. 135. — *Ixodes albipictus*, white-spotted tick of moose. *a.* Mouth-parts. *b.* Six-footed young. *d.* Foot with sucking disc. *c.* Adult, natural size, gorged with blood.

By this metamorphosis the forms are enabled to withstand desiccation, while a slight exposure to dryness kills the normal forms. The species of *Typhlodromus* usually occur on plants, where they eat the epidermis of the leaves.

The IXODIDÆ, or family of ticks, embraces the largest individuals of the Acarina. The body is enclosed in a leathery skin, the palpi are four-jointed, enclosing the denticulated beak, which is formed of the chelicerae and labrum. Eyes are sometimes lacking, and the legs are slender, terminating with two claws. *Ixodes* is the typical and largest genus, embracing the forms commonly known as ticks. These live in the woods, and attach themselves to cattle, dogs, and man whenever they have a chance. Here they suck the blood until the body swells up so that it resembles a pea. Several American species have been described, mostly by Dr. Packard, the White-spotted Tick, *Ixodes albipictus*, being possibly the best known. The European *Ixodes ricinus* attaches its eggs to its body by a clear fluid which flows from the mouth, and this, together with the position of the opening of the oviduct, which is very far forward, gave rise to the idea that the female laid its eggs through the mouth.



FIG. 136. — *Ixodes ricinus*, female. *a*, *b*, *c*, *d*, *e*. Mouth-parts. *g*. Stigma. *h*. Genital opening. *i*. Anal valves.

The genus *Argas*, which is blind, contains two well-known species, the *A. reflexus* of Europe, which is parasitic on birds, especially on doves, and *A. persicus*, of Persia and adjacent countries, which lives in houses, and by its punctures produces convulsions in man, and it is said that even death has resulted from its sting. Another less known form, *Argas nigra*, the Pique, produces distressing, and sometimes even dangerous, sores on men and cattle.

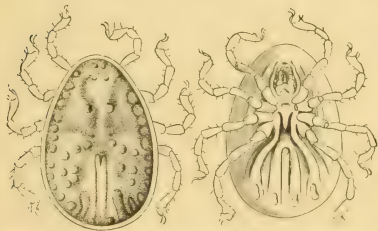


FIG. 137. — Upper and under surface of *Argas reflexus*, dove-tick, enlarged.

have been more extensively studied. These forms have the body hard and horny, the ocelli almost obsolete, the mandibles chelate, and the palpi four-jointed and short. The legs are fitted for walking, and terminate in from one to three claws. The sides of the cephalothorax are frequently expanded, and bear on their edges two

But little is known of the American species of the next family, the ORIBATIDÆ, though the European species

or three pedicellate stigmata. The forms are all terrestrial, occurring under moss, the bark of trees, and stones. The American *Oribates concentrica* and *glabrata*, are blackish species, while *O. ovinorus* is a reddish brown. The latter species has been observed by Dr. Packard to eat the eggs of the canker-worm. *Hoplophora arcata* in its shape strongly reminds one of a fresh-water mussel. The cephalothorax is much smaller than the abdomen, and so flexibly articulated that it folds over the latter, as Dr. Riley expresses it, like "the lid of a box, whenever the animal withdraws its head and limbs, which it does on the slightest disturbance." Some of



FIG. 138.—*Oribates ovinorus*, enlarged.

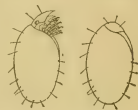


FIG. 139.—*Hoplophora arcata*, enlarged, showing two positions assumed.

the species are said to be hatched with eight legs, but one is known to have only six on emerging from the egg.

The members of the family GAMASIDÆ are parasitic upon other animals, attaching themselves to the outside of the body. They have the mandibles chelate, the legs equal and hairy, with two terminal claws and no ocelli. Frequently specimens of carrion beetles (Silphidæ) are found covered with minute bright-orange parasites. These usually belong to the genus *Gamasus*, and are nearly allied to if not identical with *G. coloptratorum* of Europe. Species of *Uropoda* also have similar habits. They attach themselves to the host by means of an anal filament of excrementitious matter; and Dr. Riley has described in addition, in *Uropoda americana*, a long and flexible organ composed of the maxillæ, each of which terminates in a pincer, which serves to attach the parasite to its host after the fracture of the somewhat brittle anal cord, or after that means of connection is broken by moulting. Bats are frequently infested with parasites of this family belonging to the genera *Pteroptus* and *Dermanyssus*. A species of the latter genus is also occasionally found on birds and poultry.

The HYDRACHNIDÆ, or water mites, have an unsegmented body, with two ocelli on the anterior portion. The legs are haired, and terminate in two claws, which in some genera are retractile into a socket in the end of the last joint. The palpi are five-jointed, and are either hooked or needle-shaped. These forms, as both their common and scientific names denote, live in the water, both salt and fresh, but most of the species are found in rivers and lakes. Many are parasitic on fresh-water beetles and bugs, at least in their early stages. Some pass their lives as parasites on the gills of fresh-water

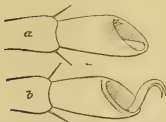


FIG. 140.—Claw of Hydrachnid. a. Retracted. b. Extended.

mussels, and others may be found running over fresh-water plants. The principal genera are *Hydrachna*, *Limnochares*, *Atax*, and *Pontarachna*, the latter being marine. *Atax ypsilophorus*, a black species with a sulphur-yellow median line, forked in front, is common to Europe and America, living in the former country in the gills of *Anodonta cygnea*, in the latter in those of *A. fluviatilis*. *Atax humerosa* is white, with dark-brown markings. It is found in *Unio cylindricus*. The eggs of the Hydrachnidæ are laid in the spring, in the stems of water plants. Dr. Packard has described a marine form, *Thalassarachna verrillii*, from Eastport, Me.



FIG. 141.—*Atax humerosa*, enlarged.

In the *BOELLIDÆ* the palpi are five-jointed, the ocelli are sometimes absent, at others they vary from two to six; the legs are long and stout. The mandibles are chelate. *Bdella*, the principal genus, is represented in America by *B. maritima*, a species occurring under stones between tidemarks, and *B. oblonga*, which has been found in Georgia under stones and the bark of trees, in rather moist situations. The latter is a bright-red species.

One frequently finds in the earth of gardens and conservatories small, slender-legged, stout-bodied red mites, their surface greatly wrinkled, and presenting the appearance of the softest velvet. Others are found upon plants. These are members of the family *TROMBIDIIDÆ*. Under the microscope it is seen that they have claw-shaped or needle-formed mandibles and short palpi.

The genus *Trombidium* is represented in the United States by three known species, *scabrum*, *sericeum*, and *holosericeum*. All three of these forms are red, and live in the ground, where they feed on the eggs of insects. Their labors in this line are so important that *T. sericeum* is mentioned as a very efficient agent in checking the ravages of the grasshopper. Another species, *T. tinctoria*, found in Guiana and Surinam, furnishes a dye. The larval forms of some species of this genus were formerly described under a distinct generic name, *Astoma*; these six-legged young are found living parasitically on other insects, clinging around the base of the wings and sucking the blood of their hosts. Larvæ of other species have been described under the generic name *Leptus*. *Trombidium* is easily recognized by its claw-shaped mandibles, and by having the first pair of legs the longest. *Tetranychus* has needle-shaped mandibles, the two anterior pairs of feet widely separated from the posterior, and two ocelli. *Tetranychus telarius*, a yellowish species with two red spots on the sides, is not uncommon on plants in greenhouses and conservatories.



FIG. 142. — *Astoma* of fly.

The last family, *PŒCILOPHYSIDÆ*, is of rather doubtful character. It was established by the Rev. O. P. Cambridge for a minute form, one-third of a line in length, from Kerguelen Island. *Pœcilophysis kerguelensis* has filiform palpi, which terminate in a single claw, while the other legs are didactylous. Its describer thinks that it combines characters of spiders, Solpugidæ, chelifers, and Acari, and has erected for its reception a possible new order, but other students of the *Arachnida* are inclined to place it among the mites.

ORDER II. — ARANEINA.

This, the second division of the *Arachnida*, contains the true spiders, and in its treatment we use, by permission, the excellent work "The Structure and Habits of Spiders," by Mr. J. H. Emerton, with such alterations and condensations as are necessary to render it conformable to the space at disposal and the plan of the present work.

The common round-web spider, *Epeira vulgaris*, will serve to show the anatomy of spiders in general. The body is divided into two parts, connected only by a narrow joint just behind the last pair of legs. The front part of the body, called the cephalothorax, contains the stomach, the central part of the nervous system, and the large muscles which work the legs and jaws. The hinder half, the abdomen, contains the intestine, the breathing-organs, the principal circulating-vessels, the organs of repro-

duction, and the spinning-organs. Connected with the thorax are six pairs of limbs — four pairs of legs, a pair of palpi, and a pair of mandibles.

The legs are used chiefly for running, jumping, and climbing; but the front pair serve often as feelers, being held up before the body while the spider walks on the other six. One or both of the hinder legs are used to guide the thread in spinning; the spider at the same time walking or climbing about with the other six or seven. The legs are seven-jointed, and on the terminal joint are three claws and various hairs and spines. In many spiders a brush of hairs takes the place of the middle claw, as in the jumping spiders. Spiders with these brushes on their feet can walk up a steep surface, or under a horizontal one, better than those who have three claws.

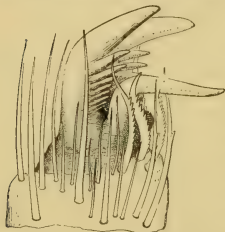


FIG. 143. — Foot of *Epeira vulgaris*.

In front of the legs are the palpi — a smaller pair of limbs, with six joints and only one claw or none. They are used as feelers and for handling food, and, in the males, carry the curious palpal organs, which will be described farther on. The

basal joints of the palpi are flattened out and serve as chewing-organs, called maxillæ.

The first pair of limbs, the mandibles or chelicerae, are two-jointed. The basal joint is usually short and stout, and furnished on the inner side with teeth and hairs. The terminal joint is a small and sharp claw, which can be closed against the basal joint when not in use.

On the under side of the abdomen, just behind the last pair of legs, are two hard, smooth patches which cover the front pair of breathing-organs, the openings to which are two little slits, or stigmata. Between these is the opening of the reproductive organs, and, in female spiders, the epigynum, — an apparatus for holding the reproductive cells of the male.

At the end of the body are the spinnerets. There are three pairs of them; but many spiders close them together when not in use, so as to cover up the middle pair. The third pair of spinnerets are often several-jointed, and extend out behind the body like two tails. In front of the spinnerets is a spiracle which leads to air-tubes which give off branches to different parts of the abdomen.

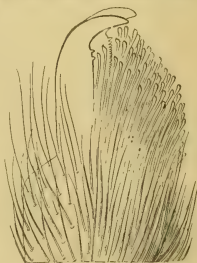
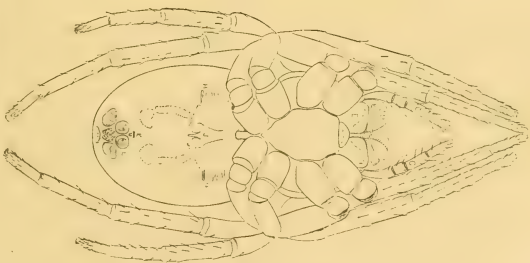
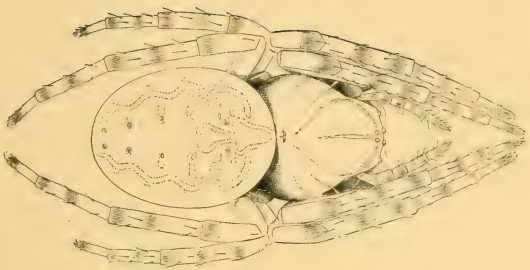


FIG. 144. — Foot of *Attus mystaceus*.

Turning now to the dorsal surface, on the front of the head are eight eyes which are differently arranged in different spiders. At the back part of the thorax is a groove, beneath which is attached a muscle for moving the sucking-stomach. On the abdomen are several pairs of dark, smooth spots, which mark the ends of muscles extending downward through the abdomen.

The mouth is just under and behind the mandibles, and between the maxillæ. It has an upper and an under lip, each lined with a horny plate, in the middle of which runs a groove. When the lips are closed the two grooves form a tube which leads to



Upper and under surface of *Epeira vulgaris*, garden spider.

C, Papil. D, Chalcidæ. H, Openings to pulmonary sacs. J, Ejaculum. K, Stigmata of tracheal system. L, Spinnerets.

the œsophagus, and so into the stomach. At the end of the œsophagus is the sucking-stomach. This consists of a flattened tube, to the top of which is attached a muscle connected with the back; and to the bottom, other muscles attached to a tough diaphragm spreading across the cephalothorax, and fastened between the legs on each side. When these muscles contract the top and bottom of the sucking-stomach are drawn apart, and whatever is in the œsophagus is sucked in. By this pumping motion the spider takes liquid food from the mouth and drives it backward into the abdomen. Just behind the sucking-stomach the intestine gives off two branches, which extend forward around the stomach muscle and meet over the mouth. Each of these branches gives off on the outer side four smaller branches which extend downward, — one in front of each leg, — uniting on the under side of the thorax. The intestine continues backward through the abdomen to the little knob behind the spinnerets. The brown mass which surrounds the intestine, and fills the abdomen above it, is the liver, which discharges into the intestine at several points.

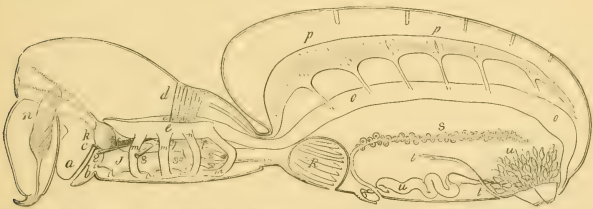


FIG. 145. — Section of *Epeira vulgaris*, garden spider. *a, b*. Upper and lower lips. *c*. Œsophagus. *d, f*. Upper and lower muscles of the sucking-stomach. *e*. Stomach. *j*. Post-oral ganglion. *k*. Brain. *l*. Nerves to the legs and palps. *m*. Branches of the stomach. *n*. Poison-gland. *o*. Intestine. *p*. Heart. *r*. Pulmonary sac. *s*. Ovary. *t*. Air-tube. *u*. Spinning-glands.

Over the intestine and parallel with it is the heart, — a muscular tube with openings along the sides to receive the blood, and branches through which it flows to different parts of the body. The greater part of the blood enters near the front of the heart, and passes backward into the abdomen or forward into the thorax. In the front of the abdomen are the principal breathing-organs, or lungs, — a pair of sacs containing a number of thin plates, through which the blood passes on its way to the heart. Besides these there is a pair of trachea opening near the spinnerets.

The spinning-glands lie above the spinnerets, along the lower portion of the abdomen. They will be more fully described when we come to discuss the webs. The reproductive organs lie along the under side of the abdomen, and open between the two lungs.

Persons unfamiliar with spiders find it hard to tell young from old, and male from female. This is caused by the great differences between different ages and sexes of the same spider. The adult males and females are, however, easily distinguished from each other, and from the young, by the complete development of organs peculiar to each sex, which will be described further on. The males are usually smaller than the females, and have, in proportion to their size, smaller abdomens and longer legs. They are usually darker colored, especially on the head and front parts of the body; and markings which are distinct in the female run together and become darker in the male.

In most species these differences are not great; but in some no one would ever suppose, without other evidence, that the males and females had any relationship to each other. The most extreme cases of this kind are *Argiope* and *Nephila*, where the male is about a tenth as long as the female.



FIG. 146.—Head of *Erigone*.

In the genus *Erigone*, which includes the smallest known spiders, the males often have curious humps and horns on their heads. The most extreme example is shown in Fig. 146, where the eyes are carried up on the end of the horn. The females of all these species have plain round heads; and what use the humps are to the males nobody knows.

The peculiar organs by which the adult males and females can always be distinguished are, in the males, the palpal organs, on the ends of the palpi; and, in the females, the epigynum.

As the male spider gets nearly full grown the terminal joints of the palpi become swollen, and, after the last moult, the palpal organs are uncovered. The simplest form of palpal organ is found in the large *Mygalidæ*. It consists of a hard bulb, drawn out to a point, in which is a small hole leading to a sac within. In most spiders the terminal joint is flattened, and has a hollow on the under side, in which the palpal organ is partly concealed. The bulb is flattened to fit this hollow, and the point of it is prolonged into a distinct tube of various shapes furnished with numerous spines and appendages. In *Theridion* the outer tube is so long that it is coiled up over the basal part of the bulb, and the end rests on a strong spine at one side of the palpus. The shape of these organs is very constant in the same species of spider, and thus they afford good characters in distinguishing species.



FIG. 147.—Palpal organ of *Theridion*.

When the female spider is nearly full grown there appears a hard, swollen place just in front of the opening of the ovaries, and after the last moult the epigynum is uncovered at this place. The epigynum consists of two sacs or spermathecae, which connect by two little tubes with the oviduct near its mouth, and by two larger tubes with the outside of the spider. The mouths of these larger tubes are often surrounded by various hard appendages. These parts, like the palpal organs, furnish convenient marks for distinguishing species. The spermathecae vary but little in shape in different spiders, but the tubes are often lengthened and twisted into shapes nearly as complicated as those of the palpal organs. Thus in the epigynum of some species of *Theridion* the larger tubes are very much elongated and twisted up, corresponding to the long discharge-tube of the palpal organ of the male of the same spider.

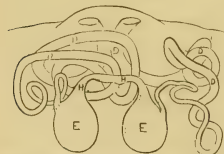


FIG. 148.—Epigynum of *Theridion*. E, Spermathecae. H, Tubes leading to oviduct. D, Tubes opening outward.

When the reproductive organs of the male spider are mature he discharges the liquid contained in them on a little web spun for the purpose; dips his palpal organs into it, and in a few moments takes up the whole into the little sacs inside the bulb; then he seeks the female, and inserts the palpal organs into her epigynum. The soft part at

the base of the organ swells up, and presses in the discharge tube, forcing out the contents of the bulb into the spermatheca, from which it escapes, in course of time, by the small tubes into the oviduct, and fertilizes the eggs about the time they are laid.

When the eggs are mature the female proceeds to make a little web and lays the eggs on it. Then she covers them over with silk, forming a cocoon in which the young remain till some time after they are hatched. The laying of the eggs is seldom seen; for the spider does it in the night, or in retired places; and often in confinement refuses to lay at all.

Many spiders make their cocoons against a flat surface, where they remain attached by one side. *Attus mystaceus* spins, before laying, a thick nest of white silk on the under side of a stone. In this she thickens a circular patch on the upper side, next the stone, and discharges her eggs upward against it. They adhere, and are then



FIG. 150. — *Attus mystaceus* laying eggs.

covered with white silk. *Epeira strix* spins, before laying, a bunch of loose silk. She touches her spinnerets, draws them away a short distance, at the same time pressing upward with the hind feet, then moves the abdomen a little sidewise, and attaches the band of threads so as to form a loop. She keeps making these loops, turning round at the same time so as to form a rounded bunch of them, into the middle of which she afterwards lays the eggs. The eggs, which are like drops of jelly, are held up by the loose threads till the spider has time to spin under them a covering of stronger silk. *Epeira vulgaris* makes a similar cocoon upward, downward, or sidewise, as may be most convenient. *Druassus* spins a little web across her nest and drops the eggs on it. They are soft and mixed with liquid, and are discharged in one or two drops like jelly. They quickly soak up the liquid and become dry on the surface, sometimes adhering slightly together. After the eggs are laid this spider covers them with silk, drawing the threads over them from one side to the other, and fastening them to the edges of the web below. When the covering is complete she bites off the threads that hold the cocoon to the nest, and finishes off the edges with her jaws.

The Lycoside make their cocoons in the same way, but rounder, and showing only slightly the seam where the upper part was attached to the lower. The *Lycosus* carry their cocoons about attached to the spinnerets, bumping them over the stones without injury to the young inside. The large species of *Argiope* makes a big pear-shaped cocoon hanging in grass or bushes. These are made late in the summer, and the young stay in them till the next season. Out of six hundred cocoons collected by Wilder in the spring less than a quarter were entire, the rest being pierced or torn in some way by birds or insects, so that the spiders were



FIG. 149. — *Druassus* laying eggs. A. Web. E. Eggs.



FIG. 151. — *Lycosus*, with cocoon attached to spinnerets.

saved the trouble of gnawing their way out. The young of *Micaria* cut a smooth, round hole in their paper-like cocoon just large enough for them to come out one by one.

The fertilization of the eggs takes place when they have reached their full size and are about to be laid. After the eggs are laid it is very easy to watch their development. They grow just as well anywhere else as in the cocoon, and, in order to see through the shell, it is only necessary to cover the egg to be examined with oil, alcohol, or any liquid that will wet it. The rate of growth varies according to circumstances.



FIG. 152. — Segmentation of spider's eggs. *a*. Before segmentation. *b*, *c*, *d*. Three stages of division.

Some eggs laid in autumn develop slowly all winter, while others laid in summer are ready to hatch in a fortnight. The segmentation is regular, but from the relations of the protoplasm and yolk we do not find the regular segmentation spheres so common in most forms, but in their stead beautifully-irregular cleavage cells, which are shown in the adjacent figures.

In about four or five days the young of the long-legged cellar spider becomes lengthened out into a sort of barrel shape, and six whitish rings run half way round it, on each of which appears soon after a pair of little knobs, one each side. These are the six segments of the thorax, and the six pairs of limbs, and their gradual growth is shown in Fig. 153, *a* to *d*. At first there is no sign of a head or abdomen; but shortly



FIG. 153. — Later stages of spider's eggs. *a*. Division into segments. *b*. Appearance of legs. *c*. Formation of abdomen and abdominal legs. *d*. Nearly ready to hatch.

after there appears an opaque knob at one end, under which is a pair of little knobs, such as appeared at first on the thoracic segments; then appear two pairs, then three, and so on, till there are six pairs, which mark the six segments of the abdomen. Up to this time the embryo has been rolled up with the under-side outward, but now it begins to turn, and in a day or two has its back outward. The constriction between the thorax and abdomen begins about this time, and in a few days more the spider is ready to hatch, Fig. 153, *d*.

The hatching occupies a day or two. The shell, or rather skin, cracks along the lines between the legs and comes off in rags, and the spider slowly stretches itself and creeps about. It is now pale and soft, and without any hairs or spines, and only small claws on its feet; but in a few days it gets rid of another skin, and now begins to look

like a spider. The eyes become darker-colored, marks on the thorax become more distinct, and a dark stripe appears across the edge of each segment of the abdomen. The hairs are long and few in number, and arranged in rows across the abdomen and along the middle of the thorax. Before the next moult they usually leave the cocoon and for a time live together in a web spun in common. Where large broods of young spiders live together they soon begin to eat one another, and if kept in confinement one or two out of a cocoon-full may be raised without any other food. The young of the running spiders, *Lycosida*, when they come out of the cocoon, get on their mother's back, and are carried round by her for some time.

As spiders grow larger they have to moult from time to time. The spider then hangs itself by a thread from the spinnerets to the centre of the web. The skin cracks around the thorax just over the first joints of the legs, and the top part falls forward, being held only at the front edge. The skin of the abdomen breaks irregularly along the sides and back, and shrinks together in a bunch. The spider now hangs by a short thread from the spinnerets, and works to free her legs from the old skin.

That which more than anything else distinguishes spiders from other animals is the habit of spinning webs. Some of the mites spin irregular threads on plants, or cocoons for their eggs, and many insects spin cocoons in which to pass through the change from larva to adult. In the spiders the spinning-organs are much more complicated, and used for a greater variety of purposes,—for making egg-cocoons, silk linings to their nest, and nets for catching insects. The spider's thread differs from that of insects in being made up of a great number of finer threads laid together while soft enough to unite into one.

The external spinning-organs are little two-jointed tubes on the ends of the spinnerets. There is a large number of these little tubes on each spinneret, and in certain places a few larger ones, each tube being the outlet of a separate gland. When the spider begins a thread it presses the spinnerets against some object, and forces out enough of the secretion from each tube to adhere to it. Then



FIG. 154. — Spinnerets of *Epeira*.



FIG. 155. End of spider's thread.

it moves the spinnerets away, and the viscid liquid is drawn out and hardens at once into threads,—one from each tube. If the spinnerets are kept apart a band of threads is formed, but if they are closed together the fine threads unite into one or more larger ones. If a spider is allowed to attach its thread to glass the end can be seen spread out over a surface as large as the ends of the spinnerets, covered with very fine threads pointing towards the middle, where they unite, Fig. 155.

The spinning is commonly helped by the hinder feet, which guide the thread and keep it clear of surrounding objects, and even pull it from the spinnerets. This is well seen when an insect has been caught in a web, and a spider is trying to tie it up. She goes as near as she safely can, and

draws out a band of fine threads, which she reaches out toward the insect with one of her hind feet, so that it may strike the threads as it kicks, and become entangled with them. As soon as the insect is tied tightly enough to be handled the spider holds and turns it over and over with her third pair of feet, while with the fourth pair she draws out, hand over hand, the band of fine threads which adhere to the insect as it turns, and soon cover it entirely.

It is a common habit with spiders to draw out a thread behind as they walk along, and in this way they make the great quantities of threads that sometimes cover a field of grass or the sides of a house.

In confinement spiders begin at once to spin, and never seem comfortable till they can go all over their box without stepping off their web.

The uses to which the silk is put are very various, the principal being in the formation of nest, webs, and egg-cocoons. Among the simplest nests are the very interesting tubes of the Trap-door spiders, principally belonging to the Mygalidæ. *Uteniza californica*, common in New Mexico, Arizona, and California, digs its hole in a fine soil, which, when dry, is nearly as hard as a brick. The holes are sometimes nearly an inch

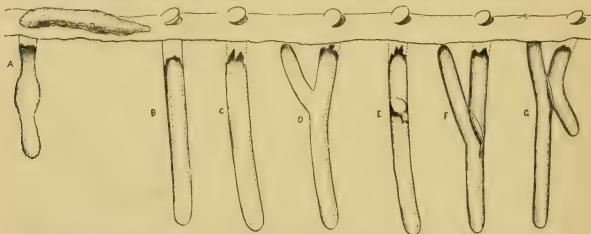


FIG. 156.—Nests of trap-door spiders. A. Nest of *Atypus*. B. Nest with thick door. C. Nest with thin door. D. Branched nest. E. Nest with two doors. F. Branched nest with two doors. G. Nest with two branches.

in diameter, and vary in depth from two or three inches to a foot. The mouth is a little enlarged, and closed by a thick cover that fits tightly into it, like a cork into a bottle. The cover is made of dirt fastened together with threads, and is lined, like the tube, with silk, and fastened by a thick hinge of silk at one side. When the cover is closed, it looks exactly like the ground around it. The spider holds on the inside of the door with the mandibles and the first two pairs of feet; while the third and fourth pairs are pressed out against the walls of the tube, and hold the spider so firmly that it is impossible to raise the cover without tearing it.

Among the trap-door spiders of Southern Europe are species which make different kinds of nests. The cover, instead of being thick, and wedged into the top of the tube like a stopper, is thin, resting on the top of the hole, and is covered with leaves, moss, or whatever happens to be lying about; so that it is not easily seen. Two or three inches down the tube is another door, hanging to one side of the tube when not in use; but, when one tries to dig the spider out from above, she pushes up the lower door, so that it looks as if it were the bottom of an empty tube.

Another species digs a branch obliquely upward from the middle of the tube, closed at the junction by a hanging-door, which, when pushed upward, can also be used to

close the main tube. In these nests the spiders live most of the time, coming out at night, and some species in the daytime, to catch insects, which they carry into the tube, and eat.

Moggridge once took a *Cheniza californica* out of her nest and put her on a pot of earth, and the next morning had the good luck to see her at work digging. She loosened the earth with her mandibles, and took it in little lumps with the mandibles and maxillae, and carried it away piece by piece. It took her an hour to dig a hollow as large as half a walnut. He saw the making of the door twice by other species. Once he dug a hole for a spider in some earth, and the next day found her in it and the top covered by a little web, on which were scattered bits of earth and leaves, which had evidently been put there by the spider. The second night enough dirt and silk were added to make the door of the usual thickness, but the spider never finished it so that it would open properly on its hinge. Another time Moggridge saw at the mouth of a very small hole a spider at work making a door. She spun a few threads across the hole, then gathered up with her front-legs and palpi an armful of dirt, and laid it on top of the threads. She then got under the pile, into the tube; but the motions of the dirt showed that she was still at work on it, and next morning the under-side had been thickly covered with web, and the whole separated from the mouth of the tube except at one side, where the usual hinge was left. The new door was at first soft, but in two or three days hardened, and appeared exactly like an old door.

These spiders are accustomed to put on the door moss like that which grows around it, and so conceal the door from sight; but when Mr. Moggridge took away the moss, and dug up the ground around a hole, and then destroyed the cover, the spider made a new one, and brought moss from a distance to put on it, thereby making it the most conspicuous thing in the neighborhood.

There is one spider, *Argyroneta aquatica*, that makes a bag of silk on water-plants, and lives in it under water, as in a diving-bell, the opening being below, so that the air cannot escape. Mr. Bell describes the filling of these nests with air by the spider. After the nest had been made as large as half an acorn, she went to the surface and returned fourteen times successively, and each time brought down a bubble of air, which she let escape into the nest. The bubble was held by the spinnerets and two hind-feet, which were crossed over them; and the method of catching it was the following: The spider



FIG. 157. — *Argyroneta aquatica*, water-spider, natural size.

climbed up on threads or plants nearly to the surface, and put the end of the abdomen out of water for an instant, and then jerked it under, at the same time crossing the hind-legs quickly over it. She then walked down the plants to her nest, opened her

hind-feet, and let the bubble go. The water-spiders run about on water-plants, and catch the insects which live among them.

The simple nests and tubes that have been described are made by spiders, most of which spin no other webs. The larger and better known cobwebs for catching insects are made by comparatively few species. On damp mornings in summer the grass-fields

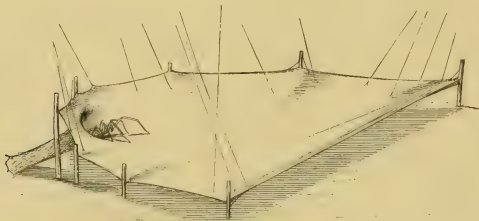


FIG. 158. — Web of *Agalena*.

are seen to be half covered with flat webs, from an inch or two to a foot in diameter, which are considered by the weatherwise as signs of a fair day. These webs remain on the grass all the time, but only become visible from a distance when the dew settles on them. Fig. 158 is a diagram of one of these nests, supposed, for convenience, to be



FIG. 159. — Web of *Linyphia marmorata*.

spun between pegs instead of grass. The flat part consists of strong threads from peg to peg, crossed by finer ones, which the spider spins with the long hind-spinnerets, swinging them from side to side, and laying down a band of threads at each stroke. At one side of the web is a tube leading down among the grass-stems. At the top the spider usually stands, just out of sight, and waits for something to light on the web, when she runs out and snatches it, and carries it into the tube to eat. If anything too large walks through the web, she turns around, and retreats out of the lower end of the tube. In favorable places these webs remain through the whole season, and are enlarged, as the spider grows, by additions to the outer edges. Similar webs are made by several house-spiders, and are enlarged, if let alone, till they are a foot or two feet wide, and

remain till they collect dirt enough to tear them down by its weight.

Nearly all spiders that make cobwebs live under them, back downward; and many

are so formed that they can hardly walk right side up. *Linyphia aurummarata* makes a dome-shaped web, supported by threads that extend up into the bushes two or three feet. The spider stands under the middle of the dome, where it draws in a small circle of web with its feet. The upper threads of the web interfere with the wings of small insects flying between them, and they fall down to the dome below, where they are seized, and pulled through the nearest hole. *Linyphia communis* makes a double web. The spider stands under the upper sheet, which curves a little downward. What the use of the lower web is is not easily seen.

The webs of *Theridion* usually have at some part a tent, or at least a thicker portion, under which the spider stands; and from this run irregularly simple threads, crossing each other in all directions, and held in place by threads above and below. Such irregular webs are often made in houses by *Theridion vulgare*, in corners of rooms, under furniture, and in cellar-stairways. The same spider spins occasionally out of doors on fences, but never on plants. When it has caught an insect, and tied it up, it fastens to it threads from above, which, as they dry, contract, and pull it up a little. It brings down more and more threads, until the insect is at last hoisted to the top of the web, where the spider can suck it without exposure. *Pholcus*, the long-legged cellar-spider, makes an irregular web of this kind, and has a curious habit when alarmed. It hangs down by its long legs and swings its body around in a circle, so fast that it can hardly be seen.

Round cobwebs are made by the family Epeiridæ, and the process of making them by the common spider, from which our figures are drawn, can be easily observed in any garden. They generally choose for their web a window-frame or fence, or some such open wooden structure, where there is a hole or crack in which they can hide in the daytime. The spider begins by spinning a line across where the web is to be, and attaches another to it near the middle. She carries the last line along, holding it with one of the hind-feet, and

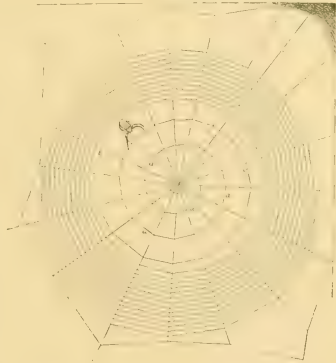


FIG. 160.—Web of *Epeira vulgaris*. *a*. Spiral thread. *b*. Radial threads. *c*. Threads to nest. The spider is seen spinning the adhesive threads.

makes it fast an inch or two from one end of the first; then she goes back to the centre, attaches another line, which she carries off in another direction and fastens; and so on until all the rays of the web (Fig. 160) are finished. She stops occasionally at the centre, turns around, and pulls at the threads one after another, and spins here and there short cross-lines to hold them more firmly. She seems, by thus feeling the rays, to decide where to put in the next one, and does it always in such a way as to keep tight what has been done before. When the rays are finished to her satisfaction, the spider begins at the centre to spin a spiral line across

them, the turns of the spiral being as far apart as the spider can conveniently reach. She climbs across from one ray to the next, holding her thread carefully with one of the hind-feet, till she gets to the right point, and then turns up her abdomen, and touches the ray with her spinnerets, thus fastening the cross-thread to it. The figure shows her in this position. When this spiral has been carried to the outside of the web, the spider begins there another and closer one, of thread of a different kind. While the

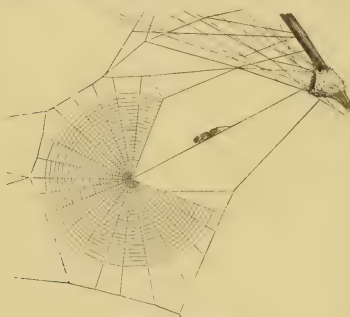


FIG. 161. — Web of *Zilla*.

first thread was smooth, the latter is covered with a sticky liquid, which soon collects on it in drops, and makes it adhere to anything that touches it. After going round a few times, this spiral would cross the one that was spun first if the spider would allow it to; but, as she comes to the old spiral, she bites it away. By beginning thus at the outside, the spider is able to cover the whole web with adhesive threads, and, without stepping on them, take her usual place in the centre. She usually is careful enough to spin beforehand a thread from the centre to her nest, and sometimes stays there, with

on foot on the thread, so as to feel if anything is caught in the web. When she feels a shake, she runs down to the centre, feels the rays to see where the insect is, and runs out and seizes it. We have described the web as consisting of one regular spiral; but this is seldom the case. It is usually wider on one side than the other, or below than above, where outside the spirals are several loops going partly round the web. The web of *Zilla* consists entirely of such loops going three-quarters round the web, and returning, leaving a segment without any cross-threads, in which is the line from the centre to the spider's nest. The web of *Nephila plumipes* also consists of loops running round about quarter of a circle; and in this web the smooth cross-lines which are first spun are not removed, but remain after it is finished.

The round-web spiders repair their webs by tearing out a dirty, tangled piece, and putting a new one in its place. Wilder says that *Nephila plumipes* tears off and replaces half the web at one time. *Epeira vulgaris* often takes away an old web, and puts a new one in the same place, tearing down the old in pieces, and putting in the rays of the new as it goes along. The spider walks on the nearest sound thread, and gathers in with her front-feet as much old web as she can tear off, and rolls it up with her palpi and mandibles into a ball. As she walks along, gathering up the old web in front, she at the same time spins a new thread behind, and, when she gets to a suitable place, makes it fast as one of the rays of the new web. The common story has it, that the spider eats the old web. She certainly gathers it up in her mouth, and sometimes throws it away at once, but at other times sits and chews it a long time, with apparent pleasure.

Various attempts have been made to use the silk of spiders, and chiefly that of the

large round-web spiders, for practical purposes, either by carding the cocoons or by drawing the thread directly from the spider. The latest experiments and plans for this purpose are those of Professor Wilder. He shows how *Nephila plumipes* might be raised in large numbers, each spider kept by herself in a wire ring surrounded by water, fed with flies bred for the purpose from old meat, and milked every day of their thread. Every day or two each spider should be taken down, put into a pair of stocks, and the thread pulled out till it stops coming. In this way he thinks an ounce of thread could be got from each spider during the summer. The thread is from a seven-thousandth to a four-thousandth of an inch thick, and much smoother and more brightly colored, as well as finer, than that of the silk-worm. Several threads would have to be twisted together to get one of manageable size. The principal difficulties are the space needed for keeping each spider by herself, and the amount of labor needed to provide them with living insects for food and to draw out the silk, which would make it too expensive to use.



FIG. 162. — Spinnerets of *Araneus*.
a. Cribellum.

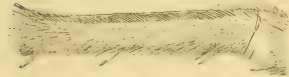


FIG. 163. — Calamistrum of *Araneus*.

The Cimiflonidae, in addition to the usual plain thread, make a peculiar kind of their own. They have in front of the spinnerets an additional spinning-organ, called the cribellum. It is covered with fine tubes, much finer than those of the spinnerets, set close together. They also have on the last joint but one of the hind-legs a comb of stiff hairs, the calamistrum.

When they spin their peculiar web they turn one of the hind-legs across under the spinnerets, so that the calamistrum is just under the cribellum, and the foot rests on the opposite leg (Fig. 164). The hind-legs are then moved rapidly back and forth, so that the calamistrum combs out from the spinning-tubes, and at the same time tangles a band of fine threads. This band is laid along, and attached here and there to a plain thread, so as to make it adhere more readily to an insect that happens to touch it. As one leg gets tired, they change and work with the other. In the webs of these spiders this adhesive band can be seen with the naked eye.



FIG. 164. — *Dictyna*, spinning curled web. a, b Smooth thread.
c. Curled thread.

Among those spiders that use the calamistrum is one which makes a web unlike any other. It has been described by Professor Wilder under the name of the triangle spider. It lives usually among the dead branches around the lower part of pine and spruce trees, and is colored so like the bark that when it stands, as it usually does, on the end of a branch it is easily mistaken for a part of it. The web seems to be made

in the night. A single thread five or six inches long runs from the spider's roost, and from its extremity radiate four branches attached to various twigs in the neighborhood. Between the rays the spider spins the peculiar curled web, and then going back toward its usual resting-place gathers up the slack of the single thread. The net is now set for use, and she stands holding it till something touches it; then she lets go with her hind legs, and the net springs forward, bringing more threads into contact with the insect. If she thinks it worth while she draws up another loop and snaps the web again. When she is satisfied that the insect is caught she gathers up part of the web till she comes to him; covers him with silk, and carries him up to her roost.

Often in summer the bushes are covered with threads attached by one end, blowing out in the wind, and bits of cobweb are blowing about with occasionally a spider attached. To account for such threads curious theories have been thought of, among others that spiders are able to force the thread from their spinnerets, like water from a syringe, in any direction they choose. If a spider be put on a stick surrounded by water she manages, in course of time, to get a thread to some object beyond, and to escape by it. To find out how this is done Mr. Blackwall tried some experiments. He put spiders on sticks in vessels of water, and they ran up and down unable to escape as long as the air in the room was still. But if a draught of air passed the spider she turned her head toward it, and opened her spinnerets in the opposite direction. If the draught continued a thread was drawn out by it, which at length caught upon something, when the spider drew it tight, and escaped on it.

There is a still more curious use of this method of spinning threads, that is in flying. Small spiders, especially on fine days in the autumn, get up on the tops of bushes and fences, each apparently anxious to get as high as possible,

and there raise themselves up on tiptoe, and turn their bodies up with their heads toward the wind and spinnerets open. A thread soon blows out from the spinnerets, and if the current of air continues spins out to a length of two or three yards, and then offers enough resistance to the wind to carry the spider away with it up into the air. As soon as she is clear the spider turns round and grasps the thread with her feet, and seems to be very comfortable and contented. Sometimes they rise rapidly and are soon out of sight, at other times blow along just above the ground.

This habit is not confined to any particular kind of spiders, but is practised by many small spiders of the genus *Erigone*, and by the young of many spiders of all families that when adult would be too large for it. The best places to watch them are garden fences, where they often swarm, and can be more distinctly seen than on bushes.

It is still unexplained how the thread starts from the spinnerets. It has been often asserted that the spider fastens the thread by the end and allows a loop to blow out



FIG. 165. — Young *Lycosa*, about to fly.



FIG. 166. — *Araneus*, about to fly by means of a brush of threads.

in the wind, but in most cases this is certainly not done, only one thread being visible. Sometimes while a thread is blown from the hinder spinnerets, another from the front spinnerets is kept fast to the ground, so that when the spider blows away it draws out a thread behind it entirely independent of the one from which it hangs. Sometimes instead of a single thread several are blown out at once, like a long brush.

When undisturbed spiders never bite anything except insects useful for food; but when attacked and cornered all species open their jaws and bite if they can, — their ability to do so depending on their size and the strength of their jaws. Notwithstanding the number of stings and pimples that are laid to spiders, undoubted cases of their biting the human skin are very rare; and the stories of death, insanity, and lameness from spider-bites are probably all untrue. The biting apparatus is shown in Fig. 167, which represents the head and mandibles of *Epeira vulgaris*, seen from in front. When not in use the claw is closed up against the mandible between the rows of teeth; but when the jaws are opened to bite the claws are turned outward, so that their points can be stuck into anything between the jaws. Fig. 168 is the claw still more enlarged, showing a little hole near the point at *a*, out of which is discharged the secretion of the poison gland. The ordinary use of the mandibles is for killing and crushing insects so that the soft parts can be eaten by the spider, and in this they are aided by the maxillæ. They will sometimes chew an insect for hours, until it



FIG. 167. — Head and mandibles of *Epeira*.



FIG. 168. — Tip of mandible, greatly enlarged. *a*. Outlet of poison-gland.

becomes a round lump of skin with all the blood sucked out of it; this is then thrown away, the spider swallowing only such bits as may happen to be sucked in with the liquid portion.

Many experiments have been tried to test the effect of the bites of spiders on animals. Doleschall shut up small birds with *Mygale javanica* and *Mygale sumatrensis*, both large and strong spiders, and the birds died in a few seconds after being bitten. The same author was bitten in the finger by a jumping spider. The pain was severe for a few minutes, and was followed by lameness of the finger, and gradually of the hand and arm, which soon went away entirely.

Bertkau allowed spiders to bite his hand. On the ends of the fingers the skin was too thick, but between the fingers they easily pricked it. The bite swelled and smarted for a quarter of an hour, and then itched for some time, and for a day after itched whenever rubbed, as mosquito bites will. Mr. Blackwall made several large ones bite his hand and arm, and at the same time pricked himself with a needle. Although the spiders bit deep enough to draw blood the effect of their bite was exactly like that of the prick of the needle. No inflammation or pain followed, and both healed immediately.

In the classification of the spiders the relative position of the eyes and the length of the legs are very important, affording both family and generic characters. The shape of the web is also distinctive.

SUB-ORDER I. — DIPNEUMONIA.

These forms have but two pulmonary sacs, and two or four stigmata. When the latter number are present, two of them open into a regular tracheal system. The mandibles work laterally. There are six pairs of spinnerets, and usually eight ocelli. This sub-order contains the great majority of the spiders, and we need here to mention but a few of the most important families, and some of the prominent forms.



FIG. 169. — *Attus*,
jumping spider.

The jumping spiders form the family ATTIDÆ. These have the body short and the cephalothorax large and square. The eyes are usually arranged in three transverse rows. They spin no web, but capture their prey by leaping upon it. Some of the species are very common. Before leaping some of the forms always fix a thread on the point from which they jump. By this they are suspended in the air if they miss their aim, and are thus secured from falling far from their hunting-grounds.

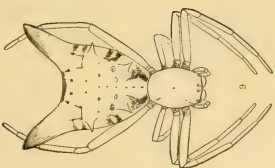
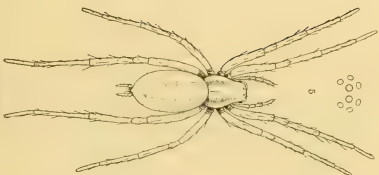
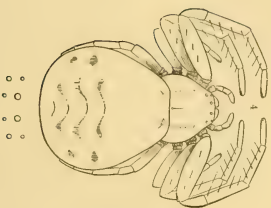
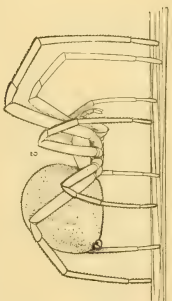
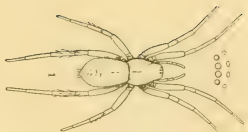
Closely allied to the Attidæ is the family LYCOSIDÆ. Like the last they make no webs, but capture their prey by running. Their long legs (the hind pair the longest) enable them to run very rapidly. The arrangement of the ocelli is shown in the cut. The cephalothorax is narrowed in front. Possibly the best-known, certainly the most celebrated species, is the Tarantula, *Tarantula apulia*, which lives in Italy and Spain. It is fabled that the bite of this spider produces epilepsy, or dancing madness, in its victims, which could only be relieved by a particular kind of music. The species of *Lycosa* and *Dolomedes*, another genus of the family, are very numerous. They live on the ground, under stones, etc.

The THOMISIDÆ have received their common name, Crab-spiders, from the fact that some species like the crabs walk better sideways than in the normal direction. They have the abdomen broad, the ocelli of nearly equal size, and arranged in two parallel urcate rows. They make no regular webs, but spin single threads by which they fasten leaves together to make their homes.

The family EPEIRIDÆ contains some of the most showy examples of the Arachnida. The two first pairs of legs are longer than the others, and the eyes are widely separated. They make circular webs, consisting of radiating threads crossed by a spiral. *Epeira*, with its numerous species, is the typical genus, and one species has served for our anatomical account of the Araneina. In this genus the abdomen is nearly globular. In



FIG. 170. — *Tarantula apulia*, tarantula, natural size.



SPIDERS.

1. *Dugesiella*.
2. *Theridion*.
3. *Dugesiella interrupta*.
4. *Thomisus*.
5. *Agelena nerioides*.
6. *Epeirina*.

Acosoma, a tropical genus rich in species, the abdomen is prolonged into a long horn on either side. *Nephila* has a long cylindrical abdomen. *N. plumipes* is found in the Southern States. The sexes differ greatly in size. Van Hasselt has made some interesting comparisons of the relative proportions of the two sexes, and says that the same dimensions applied to the human species would result in a man six feet in height and weighing 150 pounds, married to a woman from seventy-five to ninety feet in height, and weighing 200,000 pounds!

Most of the Epeiridæ are brightly colored, and make no attempt at concealment when in the web. Others have odd shapes and colors, and hang in the web in such positions that they look like anything but animals. Some species draw up their legs against their triangular abdomens, and look like bits of bark fallen into the web. Some are long and slender, and when at rest, either in the web or out, lay their legs close together before and behind their bodies, so as to look like straws. Others have oddly shaped abdomens, under which the rest of the body is partly concealed.

The THERIDIIDÆ is the largest family of Spiders. Its members have the first pair of legs the longest. The webs are more or less irregular in shape, and the species always live upside down, hanging by their feet from the under side of the webs. They



FIG. 171. — *Epeira diademata*, cross-spider; above, the arrangement of the eyes.



FIG. 172. — *Acosoma arcuata*.

are almost invariably found in shady places. *Theridion vulgare*, a species which varies greatly in color, from a cream white to a livid brown or plumbeous, is very common in houses, and with *Tegenaria domestica* shares the common name, house-spider. In *Pholcus* the legs are very long and slender. *Erigone* embraces some of the smallest spiders known. To this family belongs also the blind genus *Anthrobia*, a species of which is not uncommon in Mammoth Cave.

The DRASSIDÆ is a large family, which has the eight eyes arranged in two rows. There is considerable variation in the relative length of the limbs, but the two middle pairs are shorter than the first and last. The species are mostly dull-colored, and live under stones, or in silk tubes on plants, but all do not spin a web for the capture of their prey. We have already referred to the habits of the water spider of Europe, *Argyroneta aquatica*.

In the species of *Drassus* the feet terminate with two claws and a bundle of flattened hairs. *Tegenaria domestica* is the common house-spider, which has followed man from the old to the new world. The species of *Clubione* are nocturnal in their habits. A favorite place for their silken tubes is under the loose bark of trees or between the boulders of a stone wall. Many species are known. The family CISTIFLONIDÆ has been separated from the last on account of its peculiar spinnerets.

The family DYSDERIDÆ is an exception to the rule, as its members have but six eyes, and a closely allied Cuban form (*Nops guanabacoa*) has but two. The first pair of legs are the longest. The species are few in number, and the American forms are far from common. They are usually found under stones, but can move very quickly when so inclined.

SUB-ORDER II.—TETRAPNEUMONIA.

This group, which, as its name indicates, possesses four pulmonary sacs, embraces the largest spiders known. It is composed of a single family, MYGALIDÆ. The mandibles are very large, and work up and down instead of laterally.



FIG. 173. — *Mygale hentzii*.

The eyes are always eight in number, and are placed close together. *Mygale* is the best known genus. It is a native of tropical and semi-tropical America. The large Bird spider of Surinam reaches a length of two inches. The body is a pitchy black, and is covered with long reddish-brown hairs. It is said that it catches small birds, kills them with its poisonous bite, and then sucks their blood. *Mygale hentzii* is a not uncommon species in the Southwestern States. The genus *Cteniza* contains the Trap-door spiders, of whose wonderful architecture an account has been given in the preceding pages. The two best known species are *Cteniza cæmentaria*, of Southern Europe, and *C. californica*, of California. *Atypus* is another

genus of the family which lives further north. According to Mr. J. Wood-Mason some of the large Indian Mygalidæ are possessed of organs for producing a noise.



Mygale aricularia, bird spider.

These consist of a comb and rasp, on the outside of the chelicerae and the inner surface of the maxillae, which by being rubbed together produce a loud noise.

The spiders of North America have been studied by Hentz, Emerton, Keyserling, and Thorell. It is estimated that there are about eight hundred species in the United States.

ORDER III. — ARTHROGASTRA.

This order is characterized by an unsegmented cephalothorax (except in the Solifugae) and a usually elongate abdomen in which the segments are more distinct, and which is joined directly to the cephalothorax without the intervention of a slender petiole as in the spiders. The chelicerae and palpi are frequently chelate. Respiration is effected by means of pulmonary sacs in the scorpions and whip-scorpions, and by tracheae in the other forms.

SUB-ORDER I. — OPILIONEA.

Here come those slow-walking, long-legged forms familiarly known as harvestmen and daddy-long-legs. They have two ocelli, small chelate chelicerae, and moderate palpi. The legs are very long, and the last or tarsal joint is broken up into a long series of articulations, sometimes as many as fifty in number. Not only in this many-jointed structure but in function as well, these elongate limbs seem to resemble antennae, for they are apparently used as organs of sense, and especially of touch, by those animals. The daddy-long-legs are perfectly harmless to man. They live on small insects, and strive to avoid the full glare of the sun though they are not nocturnal in habits.

Members of this sub-order are found in all parts of the world, and in tropical countries, especially in South America, they assume the most bizarre forms. Three families are described.

The GONYLEPTIDÆ have the body broad and de-

pressed, and the palpi and hinder femora spined. The species are largely South American, *Gonyleptes curvipes* occurring in Chile. *Phryxus longipes* is found in Mammoth Cave, Ky. The family PHALANGIDÆ embraces our more common forms. Fifteen species of *Phalangium* are known from North America; in the northern

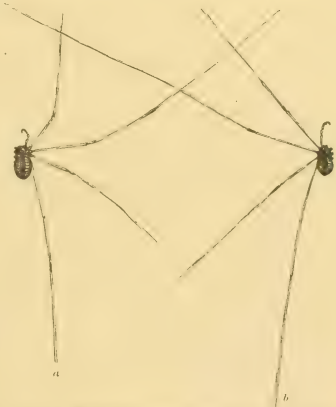


FIG. 174. — *Phalangium dorsatum*, daddy-long-legs. a. Female. b. Male. Natural size.



FIG. 175. — *Cosmetus ornatus*, male, natural size.

states *Phalangium dorsatum*, a grayish species with a darker dorsal band, is very common. *Cosmetus ornatus* occurs in the southern states, while *Acanthocheir armatum* is a blind form found in Mammoth Cave. These forms have an inflated, oval body, and the hinder femora unarmed. The family TROGULIDÆ, with a flat, elongate abdomen and the cephalothorax produced forwards, covering the mouth-parts like a roof, has not been reported from America.



FIG. 176. — *Gonyleptes curripes*.

SUB-ORDER II. — PEDIPALPI.

These forms, which are commonly known as whip-scorpions, are all inhabitants of tropical and semitropical countries. They have eight ocelli, two in the median line and three on either side. The chelicerae are short and two-jointed, while the palpi are long and large, terminating in a more or less

perfectly formed pincer. The first pair of legs is the longest, and the tarsal joint is broken up into a long series of articles, well shown in our figure of *Phrynus*. The abdomen is slightly constricted at the base, and is composed of eleven or twelve joints. There are two pairs of stigmata.

Two well-marked types exist, forming the genera *Phrynus* and *Thelyphonus*, each of which may be regarded as forming a family to which the names PHRYNIDÆ and THELYPHONIDÆ are respectively applicable.

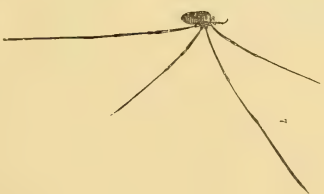
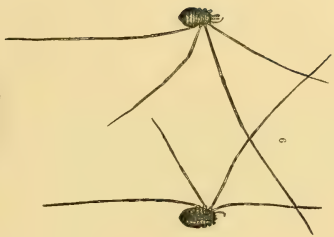
In *Phrynus* the palpi are very long, the carpal joint strongly spined. The first pair of legs are long, and both the tibial and tarsal joints are broken up into a series of rings. The abdomen is oval. The young are born alive. The species are all tropical, none occurring within the limits of the United States, though *Phrynus asperatipes*



FIG. 177. — *Acanthocheir armata*, enlarged.

occurs in Lower California; a second species is found in the West Indies, and two more are known from Southern Mexico and Central America. Other forms are found in the tropics of both hemispheres.

Thelyphonus is much more scorpion-like in appearance, and to the species of this genus the name whip-scorpion is most applicable. The palpi are short and stout, and the joints are covered with stout, sharp spines; the first pair of legs is very long, but only the tarsus is broken up into small joints. The abdomen is long and somewhat slender and twelve-jointed, the last three joints being much smaller than the rest.



HARVESTMEN.

1. *Pseudangium ventriosum*.
2. *P. pictum*.
3. *P. nigrum*.
4. *P. maculosum*.
5. *P. formosum*.
6. *P. cinereum*.
7. *P. culcar*.

From the last joint arises a long, jointed, caudal appendage, much like a whip-lash in appearance. The species are found in both hemispheres, but in the eastern hemisphere it is said by Stoliczka that none are found west of India and Ceylon, not even in East Africa. But one form, *T. giganteus*, has been found in the United States.

The species of both of these genera are very difficult to identify, and much difference of opinion exists concerning them. Like many of the arachnids they are furnished with a poison apparatus which here, as in the true spiders, is placed in the chelicerae. Of the development of the Pedipalpi nothing is known.



FIG. 178. — *Phrynos lunatus*.

SUB-ORDER III. — SOLIFUGÆ.

These forms are readily separated from all other arachnids by the segmented cephalothorax. The body is long; the chelicerae are chelate, and the palpi resembles



FIG. 179. — *Thelyphonus caudatus*, whip-scorpion.

the true legs. Specimens are far from common in the United States, but thanks to the late J. Duncan Putnam our native forms are very well known.

There are fifteen genera, two of which (*Datynus* and *Cheobis*) are represented in the United States by nine species. These forms, which are found in the warmer parts

of the world, are nocturnal in their habits, hiding during the day under stones, etc. They are very active and pugnacious, and are reputed to be very venomous, but the effects of their bite are probably considerably exaggerated. *Solpuga araneoides*, a very hairy species, is found in the region of the Volga.

SUB-ORDER IV. — PSEUDOSCORPII.

As their name indicates, these small forms closely resemble the true scorpions in appearance, but one important distinction is at once noticeable; the long and slender termination of the abdomen with its poisonous sting is absent. The chelicerae are rudimentary and fitted for sucking, while the palpi are large and stout, each terminating

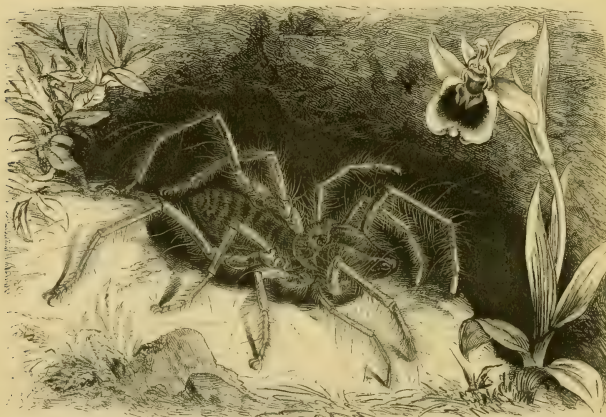


FIG. 180. — *Solpuga araneoides*.

in a pincer as in the true scorpions. Two or four or no ocelli are present, and the abdomen is eleven-jointed. They breathe by means of tracheæ.

Nine genera, represented by forty living and eleven fossil species, are known, but in the United States only the genera *Chelifer*, *Chernes*, *Chthonius*, and *Obisium*, with nine species, have been found. The fossil forms occur in amber and copal, and one species has been found in the coal formations. These forms are all small, none exceeding a few lines in length. They occur under moss and bark of trees, and one species at least (*Chelifer cancrinoides*) is not uncommon in houses and books. They are frequently found attached to insects, especially to flies, but whether this is from a parasitic habit or from a desire for a more rapid locomotion is uncertain. The probabilities are in favor of the latter. The food is supposed to be the juices of other insects, for which their sucking mouth-parts especially adapt them.

After laying, the eggs are carried by the female attached to the first segment of the abdomen, and, according to Metchnikoff, the development is much different from that of the scorpions.

SUB-ORDER V.—SCORPIOIDEA.

With the exception of the spiders the scorpions are possibly the most familiar, at least by reputation, of any of the Arachnida. They have an elongate body, the last six segments of the abdomen being of nearly equal size, forming a flexible tail armed on the tip with the well-known and much-dreaded sting. The chelicerae are short and end in a pincer, while the palpi are long and also terminate in a forceps. The ocelli vary from six to twelve, and their numbers were formerly employed to distinguish the different families. On the under surface is a peculiar pair of comb-like appendages, just behind the last pair of feet. The respiration is effected by two pairs of pulmonary sacks, which communicate with the exterior through four stigmata.

The young are developed within the mother. After birth the mother apparently shows great regard for the young, which she carries for some time about with her, attached by their pincers to all portions of her body.

Mr. J. Wood-Mason, the able naturalist of Calcutta, says that in *Scorpio afer*, and some other forms, there are well-developed organs for producing sounds. These stridulating organs are composed of a scraper on the outside of the terminal joints of the palpi, and a rasp occupying a corresponding position on the first pair of legs. When these are rubbed against each other a noise is produced.

Scorpions are especially noted as venomous insects. The sting is the sharp point of the last segment of the

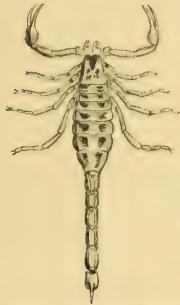


FIG. 182. — *Euthus carolinus*, scorpion, natural size.

abdomen. In this segment are the two poison glands which empty through two minute orifices near the point of the sting. When irritated the scorpions, apparently fully aware of their power, show great fierceness, waving their abdomen about in a most threatening manner, and when the opportunity occurs a sudden straightening of the hinder portion of the body forces the sting into the offending object. The sting of the scorpion rarely if ever proves fatal to man, but the larger species, especially in the warmer



FIG. 181. — Under surface of scorpion. c. Combs. s. Spiracle.

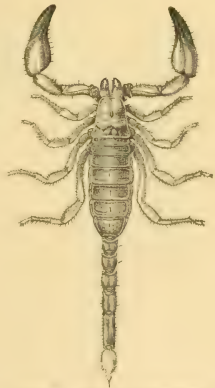


FIG. 183. — *Centruroides phidolactylus*, scorpion, natural size.

climates, produce very severe wounds which are attended with serious constitutional derangement. Jousset, who has studied this subject, concludes that the poison of the scorpion acts directly on the red corpuscles of the blood and on them alone. The poison causes them to unite together in masses too large for entrance to the capillary system, and thus the circulation is obstructed. The best remedy is ammonia applied externally, and also administered in small doses internally.

In the older schemes of classification the number of ocelli was used to divide the group into families, but in the system now in vogue the shape of the sternum is employed, together with other characters. The family ANDROCTONIDÆ has this region sub-triangular, in the TELEGONIDÆ it is very short, while in the VEJOVIDÆ and PANDINIDÆ it is sub-pentangular. These four families contain thirty-one genera, represented by numerous species in the warmer parts of the globe. Nearly twenty species are known from North America. While most of the species are comparatively small the *Scorpio ajer* of the East Indies reaches a length of nearly six inches. The species figured are all American.

The scorpions are among the most ancient of the arthropods, forms closely allied to those living at the present time being found in the rocks of the carboniferous age of both Europe and America.

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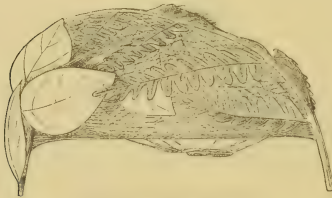


FIG. 184. — Nest of spider (*Dolomedes*).

SUB-CLASS III.—MYRIAPODA.

The group of centipedes, millipeds, and thousand-legged worms, receives both its scientific and popular names from the large number of locomotive organs possessed by the various individuals. In scientific terms myriapods may be defined as terrestrial arthropods, with distinct head and numerous similar post-cephalic segments; there is a single pair of antennæ, and two pairs of jaws; the legs are numerous, and the respiration is by trachea.

In external form, as well as internal structure, the myriapods present many similarities to the larvæ of the hexapods. The nervous system is composed of a long series of similar ganglia, one to each segment. The digestive canal, with rare exceptions, pursues a straight course through the body. The long heart extends through all the body segments and forces the blood forward. In some forms the mouth-parts are adapted for sucking. Ocelli are usually present. The young hatch from the egg with a varying number of appendages, many having but three pairs, thus showing a marked resemblance to the larvæ of many of the hexapods. Three well-marked groups are found.



FIG. 185. — Young myriapod (*Strougalassoma*, just hatched.

ORDER I.—CHIOGNATHA OR DIPLOPODA.

These are the millipeds proper. The body is round or flattened, the feet are inserted close together, and all the segments behind the third bear two pairs of limbs. They frequent dark places, and feed largely on decaying vegetation. Many have the power of curling themselves in a spiral when disturbed.

The POLYZONIDÆ have a very small head; the mouth-parts are united so as to form a sucking tube, and the eyes are few or wanting. The IULIDÆ have a large head, free mouth-parts, and a cylindrical body. The various species of *Iulus* are known as galley worms, and are not uncommon in decaying timber and similar locations. When disturbed they coil themselves into a spiral like a watch-spring, and also emit a strong odor. This is produced by glands inside the body which open on the sides of the segments, the small openings superficially resembling spiracles. The odor is evidently a provision for defence. In *I. canadensis*, a chestnut-colored species with a black dorsal band, these openings are ringed with black, thus making them more prominent. The LYSIOPETALIDÆ are closely related to the Iulidæ. They have numerous ocelli, except in the blind forms, and seven-jointed antennæ, and the body is constricted behind the head. The forms are mostly small.

We figure *Scoterpes copei*, a blind form found in Mammoth Cave.

The POLYDESMIDÆ have the sides of the segments expanded in broad plates, and the segments themselves are comparatively few. The POLYXENIDÆ embraces forms



FIG. 186. — *Scoterpes copei*.

with even fewer segments (nine to eleven), and but thirteen pairs of feet. The species are all minute. The remaining family, GLOMERIDÆ, which has twelve or thirteen

segments, and from seventeen to twenty-one pairs of legs, is not represented in the United States.

Mr. Scudder has proposed the name ARCHIPOLYPODA for a group of fossil myriapods, which, while closely related to the Chilognatha, show several important points of difference. The dorsal part of each segment



FIG. 187. — *Polydesmus*, enlarged.

(tergum) is much smaller than in that group, and is armed with huge spines. The sterna are proportionately very large and bear between the bases of the feet peculiar crater-like cups, supposed by Mr. Scudder to be the possible supports for gills, but more probably they are comparable to the similar openings on the ventral surface of *Scolopendrella*. While Mr. Scudder considers the group as a sub-order, Dr. Packard thinks that the characters are of not more than family rank. Almost all the known forms come from the carboniferous, of Mazon Creek, Ill., a few having been found in Great Britain.

ORDER II. — PAUROPIDA.

This group, which was first recognized by Sir John Lubbock, the banker-naturalist of London, forms, to a certain extent, a connecting link between the chilognaths and chilopods, while in many respects it is distinct from both. There are but six segments in the body behind the head, while the antennæ are greatly different from anything found in the whole class of insects, the basal joints bearing three flagella. Two well-marked types, represented by four species, are found in America, — *Pauropus*, with a rounded body, and *Euryypauropus*, in which the lateral edges of the body are so expanded as to completely hide the feet. These forms, which live in damp places, are very minute, about one twentieth of an inch in length. The young are hatched with three pairs of feet.

ORDER III. — CHILOPODA.

This order contains those flattened forms to which the name Centipedes is most applicable. They have long, many-jointed antennæ, and but a single pair of limbs to each segment of the body. They are predacious in their habits, moving rapidly, and living largely upon animal food. Many of the forms are poisonous. They have poison glands in the base of the first pair of legs, which are so modified as to lead to their being formerly regarded as mouth-parts, — these poison glands emptying by ducts which terminate in the same way as the similar organs in the spiders.

In the GEOPHILIDÆ the segments are similar and very numerous, varying from thirty to two hundred; the eyes are lacking; the antennæ are fourteen-jointed, and the legs are short, terminating in single-jointed tarsi. As indicated by the name,

these forms are terrestrial in their habits, living under stones and decaying wood, and preying upon the smaller insects which are found there. The genera are largely founded upon the shape of the anterior segment of the head, and upon the structure and form of the mouth-parts. *Geophilus*, the typical genus, has the anterior segment of the head square. The European *G. electricus* (which belongs to the section *Arthronomalus*) is phosphorescent, shining in the dark like a glow-worm. *Strigamia elliptica*, of Oregon, which reaches a length of five and a half inches, is the largest member of the family known.

The SCOLOPENDRIDÆ are characterized by usually possessing four ocelli on either side, seventeen to twenty-jointed antennæ, and usually unequal body-segments. To some of these characters an exception occurs in *Cryptops*, which is blind, and which has equal segments; further characters of this genus are seventeen-jointed antennæ, and twenty-one body-segments and pairs of limbs, each of which terminates in a single-jointed tarsus. *Scolopendra*, the typical genus, has eighteen or twenty joints in the antennæ, twenty-one segments and appendages and two-jointed tarsi. The species of *Scolopendra* are inhabitants of the warmer climates, and are the famous centipedes of fact and fiction. The largest known species is *S. gigantea* of the East Indies which reaches nine inches or even a foot in length. *Scolopendra morsitans*, of South America, is nearly equal in size.

The larger forms of centipedes are celebrated for their poisonous bite, which is fatal to insects and other small animals, and very painful and even dangerous to man. To us the centipedes are far from pleasant objects, especially when regarded as articles of food; but Humboldt says that the children of some of the South American Indians extract large specimens from their holes, and having torn off the head with its poisonous fangs, eat the remainder with evident gusto.

Several species have been found within the limits of the United States. Our largest form is *S. castaneiceps*, which reaches a length of five and a half inches. It is found throughout the Southern States. Our other forms are smaller, and their bite is far less venomous than that of the large tropical species.

The LITHOBIDÆ have a body with unequal segments, there being nine large and six smaller dorsal scutes. There are numerous ocelli on either side of the head, and the antennæ are many-jointed. There are fifteen pairs of feet. *Lithobius*, with forty jointed antennæ, flattened head, and two-jointed tarsi, is represented by *L. americanus*, a widely distributed American form.

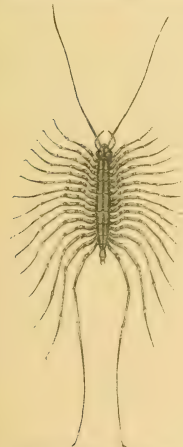


FIG. 189. — *Vermatid forelegs*, natural size.



FIG. 188. — *Geophilus brevicornis*, enlarged.

The species of this genus prey largely upon earth-worms and insects, to which their bite is poisonous.

The CERMATIDÆ have the antennæ bristle-like and longer than the body; the legs are also very long, and faceted eyes instead of ocelli, are present—an exceptional feature among the myriapods. Our only species, *Cermatia forceps*, which is rarely found in New England, but which is more common in Philadelphia and the South, is a beautiful form; its general color is a greenish brown, sometimes inclining towards purple, the body and legs being striped and banded with green. It is commonly reputed to be poisonous, but authentic cases of its bite are at least rare.

As a rule the Myriapoda are beneficial to the agriculturist. The carnivorous forms destroy immense numbers of injurious insects, while most of the vegetable feeders live on decaying wood and plants, thus converting them into the very best form of plant food. All, however, are not so innocuous, for some forms, especially the galley worms, are known to eat the roots of plants or even to attack the fruit of the strawberry, cucumber, etc. These forms are often erroneously included under the term wire-worms by gardeners and farmers.

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FIG. 190. — *Lithobius americanus*.

SUB-CLASS IV.—HEXAPODA.

The Hexapoda, or insects proper, derive their systematic name, which means six-footed, from the fact that the adults (with a few inconspicuous exceptions) have three pairs of feet fitted for locomotion. Besides this there are many other correlated and distinctive characters, and the group is as well defined and as closely circumscribed as any in the animal kingdom. The body of all hexapods is divided into three well-marked regions,—head, thorax, and abdomen,—each composed of a number of segments. In the larval stages these distinctions are frequently not so easily traced as in the adult, but still they can be readily recognized. In our discussion of the morphology of the hexapods we will first give the characters of the adult and afterwards those of the larval and pupal stages.

The head, which, as has been stated on a preceding page, consists of four segments, bears a pair of compound eyes and usually two or three simple eyes in addition. There is but one pair of feelers or antennæ, and three pairs of mouth-parts. The most anterior of the appendages connected with the mouth are the mandibles, which are always without the palpi so common in the Crustacea; next come the maxillæ, and then the labium, both of which bear articulated prolongations known respectively as maxillary and labial palpi. Besides these, there are other parts concerned in eating, which, though not appendages, deserve mention here. These are the labrum or upper lip, and the metastoma, lingula or tongue. These mouth-parts are variously modified in different insects, thus affording most important systematic characters. In the Lepidoptera they form a long sucking-tube which, when not in use, may be coiled in a spiral, while in the Hemiptera and many Diptera, in addition to being adapted for suction, they form a piercing organ. In all the other orders the mouth-parts retain more nearly their primitive character, and are fitted for biting.

The second region of the body, the thorax, is composed of three segments, each of which bears a pair of legs, and in addition the two last usually bear a pair of wings. To each of these rings of the thorax a distinctive name is applied, and since these portions are very important and often referred to the names may here be given. The first is the prothorax, the second mesothorax, and the third and last metathorax. Sometimes all of these rings are distinct and equal, but more frequently one is enlarged at the expense of the other two. Thus in the Hemiptera, Coleoptera, and many Orthoptera, the prothorax is very large, while in the others it is relatively much smaller.

Of the legs we need here say nothing, referring the reader to page 90 of this volume. The wings, however, deserve a passing notice. According to the older views of morphology these organs were regarded as modified limbs, homologous with the legs, but the present view regards them as but extensively-developed folds of the skin, comparable to the respiratory organs. The wings never exceed two pairs in number, and in the Diptera only one pair is well developed, the posterior being represented by little stalked balls, the halteres. Usually the wings are strengthened by veins, each of which has its proper name. Though the patterns of venation in many forms seem very complex, they are readily referable to a common plan, the outlines of which may be obtained in any handbook of entomology.

The abdomen, which encloses most of the vegetative and all of the reproductive organs, is composed of ten segments which are but rarely provided with appendages in the adult condition. An exception to this may be noted in the fact that the stings and ovipositors of many forms are in reality composed of the modified appendages of the last three segments of the abdomen.

Among the most striking features of the Hexapoda are the wonderful metamorphoses undergone by many members of the group in passing from the larval to the adult condition. A few forms are ovoviviparous,—that is bring forth living young,—but the great majority lay eggs which in the course of time hatch out the young. The eggs of many forms are very interesting from the peculiar and beautiful ways in which their surface is ornamented. The eggs undergo a partial segmentation, the central portion not dividing, and soon from the cells thus produced an envelope arises which from being formed in the same way as one of the fetal envelopes in the mammalian embryo has received the name amnion. This finally envelops the whole of the egg; soon a portion of the egg proper becomes differentiated, forming an embryonic disc which soon becomes divided into the future segments of the body. On each of these primitive segments there frequently appears a pair of small swellings, the rudiments of the future limbs. Frequently, however, some of the segments show at no time any trace of appendages. With the progress of growth the embryo acquires what is known as a larval condition, and then the egg hatches and the young begins a free life.

The term larva is applied to very varying stages of development as far as organs and perfection of parts are concerned, but the word may be defined in general terms as applying to the young insect just after hatching. In the grasshoppers, for instance, the larva closely resembles the adult, the most prominent difference being that the wings are extremely rudimentary. In the Diptera, on the other hand, the body is long and slender and without limbs, and, in some forms, even a distinct head is lacking. Between these two extremes almost all gradations can be found. The larvæ of Diptera (flies) are known as maggots, of the Lepidoptera (butterflies and moths) as caterpillars, and those of the Coleoptera (beetles) as grubs. The early stages of the other orders have received no popular names.

Between the larval and adult conditions the features of growth are as different as the characters of the larvæ, but the phenomena exhibited may be roughly divided into three groups. In the first (ametabolic) the insects undergo no metamorphosis, and the adult, which never has wings, differs from the larva in little else except size. The second (hemimetabolic) type passes through what is known as an incomplete metamorphosis. The larva increases in size by numerous moults and passes into a pupal condition, in which the wings are rudimentary and the general adult form is apparent. This pupa, however, is markedly different from that of the next group, in that they are active instead of quiescent. This type of development is exemplified in the grasshoppers, dragon-flies, bugs, etc.

The last, the holometabolic or complete metamorphosis, occurs among the bees, butterflies, flies, beetles, etc. We may take for an example of this type one of our American silk-worms. The larva upon hatching eats voraciously, the consequent growth being permitted by numerous moults, until at last the young insect is ready to enter the pupal stage. The larva has mouth-parts adapted for biting, three pairs of thoracic legs, while five of the abdominal segments bear locomotive appendages known as pro-legs. During the later stages the wings of the perfect insect begin their devel-



Carrion beetles and flies.

opment as scale-like pads within the larval skin, no trace of them being visible from the exterior. In the larvæ of other insects which undergo a complete metamorphosis, the abdominal appendages may be reduced in number, and may be entirely wanting, and even the thoracic legs may disappear.

When about to pass into the pupal stage, the silk-worm spins a fine thread, which it coils into an oval case known as the cocoon. Frequently in spinning this cocoon leaves are included, so



FIG. 191. — Larva of Polyphemus moth (*Tetra polyphemus*).

that the envelope is a compound of silk and leaves. Other forms do not spin a cocoon, but, with this exception, the process of metamorphosis is essentially the same. Now by a moult the pupal condition is attained. The body is enveloped in a chitinous integument, and on the anterior and ventral portions may be seen the sheaths which cover the wings, legs, antennæ, and mouth-parts. In the form under discussion these sheaths are all closely united to the body, but in others (*e. g.* beetles) these parts are all distinct and separate. The length of pupal life varies from a few days or

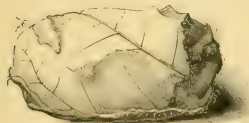


FIG. 192. — Cocoon of *Tetra*.

weeks to several months, and in the case of some beetles evidence is not lacking to support the opinion that the pupal stage may last for many years.

At last the insect is ready to enter its perfect state. It moults for the last time and emerges from its pupal envelopes. In the case of the Lepidoptera, the wings are moist flabby sacs, but soon they are distended by fluids which are forced into them, and then, drying rapidly, they acquire the firmness necessary for their use as organs of flight. By taking a moth when it has just emerged from the cocoon, one can easily produce deformed wings by pinching or puncturing these members, thus preventing their distension.

In the moth which we have taken as the type of complete metamorphosis, the mouth-parts have lost their capacity for biting, and some of them have been converted into a long tube adapted for sucking the nectar of flowers, the antennæ are transformed from short and inconspicuous organs into long feathery feelers, the compound eyes appear, the thoracic legs become longer and more slender, and the full complement of joints is produced, while the pro-legs of the abdomen have entirely disappeared.



FIG. 193. — Pupa of *Tetra*.

Correlated with these external changes so superficially reviewed are as great and important modifications of the internal organs. The reproductive organs acquire their adult functions, the digestive organs become adapted to the changed food, the

tracheal system has a different distribution, and equally important changes occur in the circulatory system. Our space is not sufficient to detail these changes, but their extent can be seen by a comparison of the adjacent figures, which represent the nervous system in the larva of a bee, and also in the adult insect. These changes are not sudden, but are accomplished by constant modifications of the organs concerned.

Besides the common sexual reproduction, some insects can produce young without the intervention of males. In some of these cases of agamogenesis or parthenogenesis



FIG. 194. — Nervous system of a larval bee.

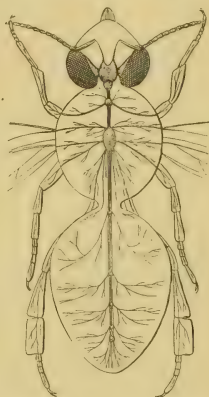


FIG. 195. — Nervous system of adult bee.

the eggs are laid and undergo the regular development of fertilized eggs, but in others the eggs are developed inside of the parent, and the young are born in an active condition.

The systems of classification of the Hexapoda are very numerous and very different, though now it is pretty universally conceded, both in this country and in Europe, that the Thysanura are the lowest and the Hymenoptera the highest orders. But within these extremes the sequence of orders varies greatly. We shall here follow Dr. Packard's latest scheme, without, however, adopting all the features of his arrangement. Dr. Packard groups the hexapods under five super-orders and ten orders, but for our purposes the former may be omitted.

ORDER I. — THYSANURA.

This order comprises the lowest, simplest six-footed insects. They are called Thysanura (from the Greek *thysaneros*, hairy or bristly, and *oura*, tail), in allusion to the hairy or bristly abdominal appendages of some of the typical forms. They are all wingless, and undergo no metamorphosis. There is a great variation in their form and structure, especially in the parts of the mouth, and it is difficult to put into few words a general account of them. They are divided into three groups of sub-ordinal rank.

SUB-ORDER I. — COLLEMBOLA.

These forms, for which the common name spring-tails may be adopted, are small, often of microscopic size; their mouth-parts are partially abortive, while they are enabled to leap by means of a curious spring beneath the abdomen. A distinctive feature of the Collembola, and one which gives the name to the group, is the remarkable organ situated on the lower surface of the basal segment of the abdomen. It is a small tubercle, consisting of two valves, from between which is thrust a fleshy sucker, or in *Sminthurus* a pair of long tubes, which are capable of being darted out on each side of the body, enabling the insect to attach itself to small objects, and even to stand upside down. There are two families. These forms are often collectively known as podurans, and furnish the "podura scales" used by microscopists as test objects.



FIG. 196. — *Papirius*. a. spring. b. sucker.

The curious little creatures, forming the family PODURIDÆ, occur everywhere except in dry places. Besides a tracheal respiration they undoubtedly breathe directly through the skin, and therefore inhabit moist places. They take up their abode under stones in damp, grassy, shaded spots, live in damp cellars, or hide under mushrooms and logs; we have seen them in greatest abundance in hot-beds, leaping in the air, and appearing like a shower of sand. One species (*Anuridæ maritima*) is often found under stones at tide-marks. A species of *Achoreutes* is sometimes found floating in large masses on the surface of roadside puddles, or under the bark of old trees; and one species sometimes abounds on the surface of the snow. On the glaciers of the Alps there is a species peculiar to that unusual habitat.



FIG. 197. — *Lepidocyrtus gibbatus*.

The podurids, as well as the sminthurids, leap by means of a curious two-forked 'spring,' which bends under the body, and when at rest is retained in place by a sort of catch; when the muscles of this catch are relaxed it lets the spring fly back, and this sends the little creature into the air, out of harm's way. The facility with which they leap is a constant source of vexation to the zealous collector, but this trait may be turned to advantage by cautiously placing over them a vial, into which they may be made to leap. The podurids are thick-bodied; the segments, though in the Thysanura generally of equal size, are in this family inclined to become unequal,

that next to the head, especially, is often small and collar-like. In the lowest forms, however, such as *Anura*, the segments are of nearly equal size. The mouth-parts are very rudimentary, they are situated mostly within the head, the jaws not being strong and adapted for biting, as in other insects; hence they only nibble decayed vegetable matter. Our commonest poduran is *Tomocerus plumbeus*, a leaden gray insect with long feelers. The species of *Orchesella* are gaily ornamented; those of *Lepidocyrtus* are white. The scales on different parts of the body are of different shapes, sometimes becoming hair-like.

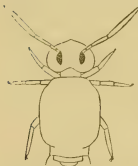


FIG. 198. — *Smynthurus aureus*, enlarged.

In the SMYNTHURIDÆ the body is globular or oval, while the legs are long and slender, and most of them are very prettily colored; they often occur on flowers. One species is often found in the spring on the flowers of the dandelion. The family name is derived from *Smynthurus*, which embraces our commonest species. The species of *Papirius* are even more minute.

SUB-ORDER II. — SYMPHYLA.

This most remarkable group contains but a single family, SCOLOPENDRELLIDÆ, and a single genus, *Scolopendrella*; and because the species have a series of abdominal legs they are frequently regarded as myriapods. By Mr. Ryder, who first called attention to its remarkable peculiarities, it is considered as the type of an order connecting the winged insects and the myriapods. These singular forms inhabit the same situations as other Thysanurans, and might be mistaken for the young of our common northern centipede (*Lithobius*). The *Scolopendrella immaculata* is found in Europe and the eastern and central United States. The head and mouth parts, as well as the antennæ, are like those of *Campodea*, but there is a series of nine pairs of five-jointed abdominal legs, which give it a myriapod-like appearance. We thus see that in *Scolopendrella* we are dealing with a remarkably composite or synthetic animal, which with fundamental thysanurus characters combines features which ally them with the myriapods. As we have already stated, the possession of functional abdominal legs by *Scolopendrella* does not imply that it is necessarily a myriapod; the feet differ in important respects from those of centipedes, and the presence or absence of abdominal feet is not an ordinal or very important character. We shall see further on that the *Cinura* (*Campodea*, *Lepisma*, etc.) have a series of one- or two-jointed abdominal appendages, which are homologous with the legs of *Scolopendrella*. At the end of the body is a pair of short, pointed stylets, which are spinnerets. This genus may be regarded as an ancestral type, *i. e.*, it is possible that the winged insects have descended from a *Scolopendrella*-like form. This view is strengthened by the fact that the embryos of many-winged insects have at first a series of abdominal feet, which disappear later on in embryonic life.



FIG. 199. — *Scolopendrella*.

SUB-ORDER III. — CINURA.

Like those of the last, the forms in this group are frequently much larger than the podurids. The mouth-parts in many respects resemble those of the Orthoptera, and the abdomen is provided with imperfect or abortive legs. From the long abdominal appendages these forms receive their scientific name, which may well be translated into a more popular form, bristle-tails.

The family CAMPODEÆ comprises two genera, which are quite dissimilar in form. The group is distinguished by the long, slender body, and by the mouth-parts, jaws, etc., being still withdrawn mostly within the head. The common form is *Campodea*, and *C. fragilis* is found everywhere under stones in shaded, damp places. It is yellowish-white, its antennæ long and slender, and its body ends in two long caudal jointed threads, about a sixth of an inch long. It looks at first sight like a young centipede (*Lithobius*), and is very agile in its movements. A much larger species (*C. Cookei*), and also differing in having longer antennæ, inhabits Mammoth Cave.

Iapyx is the other genus of this family. It is rather more highly developed than *Campodea*, and differs in the body ending in a pair

of stout forceps. While *Campodea* has a series of little one-jointed movable appendages along the under side of the body *Iapyx* has none. Our North American species is *Iapyx subterraneus*, which is found under stones at the mouth of a small grotto near Mammoth Cave. Another species occurs in Mexico.

We now come to the bristle-tails proper (LEPISMATIDÆ). These agile creatures are seen gliding swiftly over the floor or walls of damp rooms or over outhouses, or running away rapidly from under up-lifted stones. The body is long and slender, either flattened or cylindrical, and covered with metallic scales. Their antennæ are long and thread-like; their jaws and feelers (palpi) are well-developed, and in general like those of cockroaches. The caudal stylets or filaments are very long, and usually finely bristled. These insects run with great swiftness, and in their structure, especially of their body-segments and legs, as well as their motions, they remind us of immature cockroaches.

In the genus *Lepisma* there are seven caudal bristles, of which three are longer than the others. The peculiar motions of these animals are due to

the nature of the legs, the tarsal joints being much as in cockroaches, broad, flat, and almost triangular. A common species in damp, shut-up apartments is *Lepisma saccharina*. It has somewhat the habits of the cockroach, eating clothing, tapestry, the



FIG. 200. — Abdominal legs of *Campodea*.

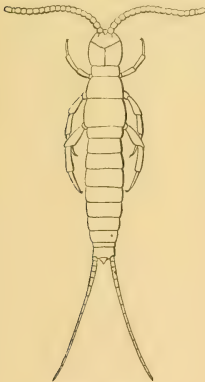


FIG. 201. — *Campodea*.

silken trimmings of furniture; and at times will injure books by devouring the paste of the binding, as well as by eating holes in the leaves and the binding. I have

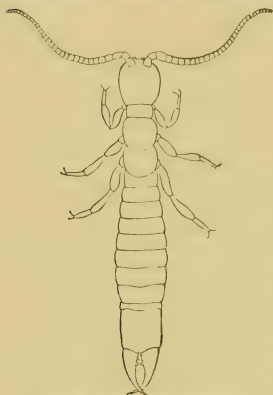


FIG. 202. — *Lepyx sotifugus*, enlarged.

seen old envelopes which had been riddled with holes gnawed by these insects.

Another species locally very common is *Lepisma domestica*, which I discovered living in great abundance in a house, especially the kitchen, about the range. This is a heat-loving species, and it may prove identical with *Lepisma thermophila* of houses in Brest, France. Our most common out-of-door species is *Lepisma quadriseriata*, which may be seen running over the walls of outhouses.

The genus *Machilis* stands at the head of the Thysanura; its advanced standing is seen in the rather large, full compound eyes, and its well-developed mouth-parts. The body ends in three bristles, but the chief characteristics are the two-jointed stylets, arranged in nine pairs along each side of the abdomen, and which remind us of the abdominal legs of myriapods. They affect damp, though not wet places, living in partial darkness under stones. Our common eastern species is *Machilis variabilis*, but other species occur in the western states.

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FIG. 203. — *Lepisma saccharina*, enlarged.

ORDER II. — DERMATOPTERA.

This order comprises the earwigs, as they are called in Europe, and is a small group, usually placed among the Orthoptera. There are, however, certain characters which forbid our placing it with that order. The fore wings are small, short, like the elytra of certain beetles, notably the rove beetles (Staphylinidae); while the large broad hind wings are very peculiar, and quite unlike those of the Orthoptera; they are folded under the fore wings, or elytra, much in the manner of beetles, and the process of folding the wings is aided by the singular forceps at the end of the body, which is also another peculiarity of these insects. The body is usually long, narrow, and much flattened. It will thus be seen that these insects are composite forms, and anticipate in a degree the beetles. On the other hand the larva resembles *Lappæ*, with its anal forceps, and upon the whole the Dermaptera stand below the Orthoptera, and indeed all the other winged insects.

But a single family (FORFICULARIDÆ) represents this order, and there are two principal genera, *Forficula*, and a short-bodied genus called *Labia*. In *Forficula* the antennæ are compound, of fifteen joints, while those of *Labia* have less than twelve.

The earwigs are nocturnal in their habits, hiding in the daytime among leaves and in flowers, and flying about at dusk. In Europe, where they are common and annoying garden pests, they feed on the corollas of flowers and on fruit, and will eat bread and meat. With us the earwigs are among the rarest of insects, but are more common in the Gulf States than northward.

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FIG. 201. — *Forficula crassipennis*.

ORDER III.—PSEUDONEUROPTERA.

It is difficult to satisfactorily characterize by a sharp-cut definition this very elastic order. The definition in Dr. Hagen's "Neuroptera" is as follows:—"Mandibulate insects with an incomplete metamorphosis (active pupa); lower lip mostly cleft; four membranaceous, reticulate wings (rarely with rudimentary wings or apterous); antennæ either subulate, and then the tarsi three- to five-articulate, or setiform, or filiform, in which case the tarsi are two- to four-articulate." This is not very satisfactory, as the characters given are for the most part of a superficial nature. It is easier to separate the present order from the Neuroptera than from the Orthoptera,

FIG. 205.—*Diplax berenice*, female.FIG. 206.—*Diplax berenice*, male.

or grasshoppers, etc. For example, the cleft labium is to be found in Orthoptera, and though, as a rule, the Orthoptera have five-jointed tarsi, the family of Mantidæ have four tarsal joints. The Pseudoneuroptera are closely connected with the Orthoptera, especially the cockroaches (Blattariae), by the white ants (Termitidæ) which in some important respects very closely resemble the former. Except in the characters above given we have been unable to discover in the trunk or body itself any fundamental characters peculiar to the Pseudoneuroptera, and which will apply to all taken together. The parts of the head, the thorax, and the abdomen, show a great lack of uniformity in the different groups, as does also the structure of the wings.

SUB-ORDER I.—PLATYPTERA.

These forms may readily be separated from those of the next group of equivalent rank by the flattened body and by the usually broad and quadrate prothorax. The sub-order contains four families, all of which are represented in our American fauna.

FIG. 207.—*Perla pallida*.

The species of the family PERLIDÆ are called stoneflies from the fact, we suppose, that they are so abundant, in the pupa state, under stones in streams, while the winged insects themselves, especially *Perla*, are to be found by anglers in such situations. In England *Perla bicaudata* is called the stone-fly; a small, greenish species, belonging to the genus *Chloroperla*, is called the yellow-sally; while a species of *Nemoura* is called the willow-fly; all these perlids are considered in England

excellent bait for trout; in this country they are not used for bait, and have received

no common names. They all have flattened bodies, and the abdomen ends in two long appendages. The larvæ are aquatic.

These insects frequent damp, wooded, shaded places, especially along the banks of brooks and rivers, where they are found throughout the summer, usually resting upon the leaves; the smaller kinds occur the farthest from the water, being less sluggish in their motions than the larger species, *i. e.*, those of *Perla* and *Pteronarcys*. The species of the latter genus are remarkable for uniformly being provided with persistent gills, which are little tufts of short, slender filaments, a pair being situated on the under side of each thoracic, and the first and second abdominal segments. Similar external gills have recently been found to occur in a few other species of the family. The males of *Perla* differ a good deal from the females, having very short wings. The Perlidæ in general have narrow flat bodies, with a large, square prothorax; the antennæ are long and thread-like, and from the end of the body arise a pair of similar-jointed appendages. A peculiarity of many of the species of this family are the soft, membranous, toothless mandibles, the flies apparently taking no solid food. The wings are peculiar, the front pair being long and narrow, while the hinder pair are twice or three times as broad. Both pairs are net-veined, there being a good many small transverse veins; when folded they lie flat on the back, extending beyond the end of the body. The tarsal joints are three in number.

In their transformations the changes of form from larva to imago are rather slight. The larvæ are of much the same shape as the imagoes but with strong horny jaws. They do not live in cases, but free under stones and sticks; the pupæ simply differ in having wing-pads or rudimentary wings; and they are active, like the larvæ. The larvæ and pupæ breathe by tufts of gills on the under side of the thorax. The females are said to carry their little, black, shining eggs in a sac or bag attached to the end of the body.

There is no common English name for the species of the family PSOCIDÆ collectively, but the most familiar member of it is the little book-louse, "death-tick" or death-watch, which is often seen running over books. The winged forms bear a striking resemblance to plant-lice or aphides, as they are of the same size, of much the same shape, their heads, antennæ and legs being of nearly the same proportions, while the wings also strikingly resemble those of the aphides in being small, folded roof-like over the body, the hinder pair being smaller than the fore pair with very few veins, and even these disposed somewhat as in those of the plant-lice. These insects are



FIG. 208. — *Psoeus lineatus*, enlarged.

common on shaded fences, and the leaves of trees. One species (*Psoeus nori-seotia*) is as large as any we have met, and abounds in New England among the leaves and twigs of evergreen trees, especially the spruce and fir. The nature of their food is not with certainty known, but they probably feed on lichens and dry vegetable matter rather than small living insects. Their movements are active, and when disturbed they will run out of sight around the tree or leaf upon which they are situated. They appear in the winged state late in summer. The species of *Coccilia* are small and pale

yellowish-green. They occur everywhere in gardens, and a common species has been observed by us to lay its eggs, from late in August until the last of October, on the leaves of the lilac, pear, and horse-chestnut. The eggs are oblong-oval, not numerous, and are covered by a flat, round web, like the 'cocoon' of a spider, but only about

a line in diameter. The development of the embryo requires but a few days, and the process of development appears to be substantially like that of other Pseudoneuroptera (*Diplax* and *Termes*). The larvæ resemble the pupæ, and the latter only differ from the adults in having wing-pads, *i. e.*, undeveloped wings. In certain genera the wings are almost undeveloped, as in *Clothilla* and *Atropos*. The little book-louse or "death-watch," the name it is known by in England, is a little dirty-white insect which is to be seen rapidly running over dusty books, and in boxes or drawers



FIG. 269. — *Clothilla pulsatoria*.

of insects, where it does considerable injury to specimens or books, feeding upon the paper. In England it is said to make the ticking sound, like that made by the death-tick beetle (*Anobium*), heard in walls of rooms, and certain popular superstitions are connected with this insect.

The family EMBIDÆ embraces but a few species of insects, and those very rare, inhabiting tropical countries, none of them occurring in the United States. They are small insects, forming a connecting link between the white ants and *Psocus*; they are characterized by the linear, depressed body, with the head free from the thorax, the wings equal in size, with few veins, and with three-jointed tarsi. The larvæ are found under stones, and are protected by a cocoon which they renew at each moulting of the skin. One of the best known species is *Embia savignyi* of Westwood, which inhabits Egypt. A species of embid (*Olythia*, referred to *Embia* by McLachlan), is stated by Dr. Hagen to occur in Cuba. Mr. J. Wood-Mason, who has recently studied these forms in India, is of the opinion that they are true Orthoptera.

The family TERMITIDÆ is perhaps the most interesting group of the order, whether we take into account the structure, or the wonderful difference in the form and habits of the various sets of individuals forming a colony. They are called white ants from the general resemblance of the wingless forms to ants, and from their color, as well as owing to the fact that they exist like ants in large numbers in mounds or "hills." These insects had established themselves in the world long before the true ants appeared, as their remains are found in the coal measures of Europe, while the true ants did not appear in geological history until the tertiary period. Hence the white ant is an old-fashioned form which has persistently held its own from the early geological ages until the present time, and this fact alone invests their history with a peculiar interest. As it is, at the present day, white ants, though mainly tropical, are wide-spread throughout the temperate regions of North and South America, and are sometimes extremely annoying from their great numbers and destructive habit of eating out the interior of articles of furniture, such as chairs and tables, or the sills of houses. For example, our common white ant (*Termes flavipes*), while usually running hidden galleries or mines in stumps or trunks of trees, often in a similar way mines the roots of grape-vines, or enters the interior of timbers forming the sills of houses, leaving but a shell. In the same way these insects in India enter houses by subterranean passages, effect an entrance into the legs of tables and chairs, mine the

interior completely, until but an empty shell is left, although the exterior appears unhurt, until some unusual shock or service causes them to fall to pieces. The annoyance from these insects in warm countries is increasing, and it is almost impossible to prevent their attacks.

Regarding the mischief done in houses by an African species (*Termes achorum*) Smeathman has given full particulars. This species builds in trees, and often establishes its nests in the roofs and other parts of houses. The entry of these white ants is difficult to guard against, since they make their approaches chiefly underground, descending below the foundations of houses and stores at several feet below the surface, and extending their mines into the floors, or entering at the bottoms of the posts of which the sides of the buildings are built, following the course of the fibres to the top. "While some are employed in gutting the posts, others ascend from them, entering a rafter or some other part of the roof." Again writes Smeathman: "They sometimes, in carrying on this business, find, I will not pretend to say how, that the post has some weight to support, and then if it is a convenient track to the roof, or is itself a kind of wood agreeable to them, they bring their mortar and fill all or most of the cavities, leaving the necessary roads through it, and as fast as they take away the wood replace the vacancy with that material; which being worked together by them closer and more compactly than human strength or art could run it, when the house is pulled to pieces, in order to examine if any of the posts are fit to be used again, those of the softer kinds are often found reduced almost to a shell, and all, or a greater part, transformed from wood to clay, as solid and as hard as many kinds of freestone used for building in England. It is much the same when the *Termites bellicosus* get into a chest or trunk containing cloaths and other things; if the weight above is great, or they are afraid of ants or other enemies, and have time, they carry their pipes through, and replace a great part with clay, running their galleries in various directions. . . . These insects are not less expeditious in destroying the shelves, wainscoting, and other fixtures of a house, than the house itself. They are forever piercing and boring, in all directions, and sometimes go out of the broad side of one post into that of another joining to it; but they prefer, and always destroy the softer substances the first, and are particularly fond of pine and fir boards, which they excavate and carry away with wonderful dispatch and astonishing cunning: for, except a shelf has something standing upon it, as a book, or anything else which may tempt them, they will not perforate the surface, but artfully preserve it quite whole, and eat away all the inside, except a few fibres which barely keep the two sides connected together, so that a piece of an inch-board which appears solid to the eye will not weigh much more than two sheets of pasteboard of equal dimensions, after these animals have been a little while in possession."

In St. Helena they have been known to seriously injure a collection of books. It has also been stated that a Spanish man-of-war, recently returned from the Philippines, was completely destroyed by a species of *Termes*, in the port of Ferrol.

The body of the wingless individuals are not only ant-like, but there is a general resemblance in the winged males and females to ants, though the body is much larger and flatter. They differ decidedly, however, from ants in the shape and structure of the wings: these are very large and long, straight and rather narrow, and finely veined, while the hinder wings are not, as in ants, much smaller than the front ones, but both pairs are of the same size, with the veins and veinlets arranged in the same manner in both. The head is of moderate size except in the workers, where it is often of enor-

mous size, and is extended horizontally, not held vertically as in ants. The eyes are rather small, rounded, and between them are two simple eyes or ocelli, a third nearly obsolete one being situated in front. The antennæ are slender, not very long, and with about twenty joints, and they are not肘ed as in ants. The jaws (mandibles) are not so long and sharp as in ants, but are shorter and stouter, more adapted for gnawing, with fine teeth on the cutting or inner edge.

The most striking features of the white ants, and in which they differ from any other of their order, is the fact that there are besides males and females certain wingless forms, called workers and soldiers. For example, if one will open a stump, or turn over a log under which our common white ant has established a colony, he will find besides the winged males and females that by far the larger number of wingless individuals are not the active larvæ but fully grown individuals, with heads of moderate size and small jaws. These are called workers, because like the wingless worker ants they perform all the various duties of the colony. Besides these a few wingless individuals will be seen which have very large square heads and large, long jaws. These are called soldiers, as they guard the nest from attack, and are bolder and more pugnacious in disposition than the smaller workers.

All the wingless individuals are sexless, the organs of reproduction being undeveloped. They may be compared, therefore, to the wingless workers among ants, or to the winged workers of bees, and should be regarded as individuals specialized or set apart for the performance of certain duties, involving the preservation of the entire colony. Indeed the winged males and females have little to do beyond providing for the continuance of the species and the preservation of the colony, the population of which is exceedingly large, the females being very prolific. The soldiers, as Smeathman long ago observed, act as "sentinels and soldiers, making their appearance when the nest is invaded, attacking the intruders and inciting the laborers to work. The more peaceful and laborious workers are estimated to be one hundred times more numerous than the soldiers." They collect food, work as miners in tunnelling their covered ways, guard the males and females, and take care of the eggs and young.

After impregnation the females, as in the case of the ants, lose their wings. They are then conducted into the interior of the nest by the workers. Here, in the African species (the gravid females of our North American species have never been discovered), the body of the female becomes enormously distended with eggs, being over two inches in length, and it is known to lay eighty thousand eggs in the course of a day.

As has been stated, there are several kinds of individuals among the white ants, and in this respect they resemble the true ants, wasps, and bees. In our common *Termites flavipes*, besides males and females there are workers and soldiers; so also with the west African species studied by Smeathman, who divides the colony or community into a king, a queen, with many laborers and a number of soldiers. Smeathman describes five species of white ants which he studied, and whose habits he records in his famous tract, published in 1781 in the "Transactions of the Royal Society of London," entitled "Some Account of the Termites which are found in Africa and other hot countries." In our author's own words: "Of every species there are three orders; first, the working insects, which for brevity I shall generally call *laborers*, next the fighting ones, or *soldiers*, which do no kind of labor; and last of all, the winged ones, or *perfect insects*, which are male and female, and capable of propagation. These might very appositely be called the nobility or gentry, for they neither labor, nor toil, nor fight, being quite incapable of either, and almost of self-defence. These only are

capable of being elected kings or queens; and nature has so ordered it, that they emigrate within a few weeks after they are elevated to this state, and either establish new kingdoms or perish within a day or two."

Latreille also enumerates four sorts of individuals in *Termes lucifugus*, a tropical form which has been introduced into France; i. e., besides males and females, soldiers and workers. In the South American white ants, however, this number is much exceeded, and the differentiation of the individual is carried on, perhaps, to a much greater extent than in any other known insects. We are indebted to Fritz Müller, who had more than a dozen living species at his disposition, for some curious details, which he first published in a letter to Darwin. Müller found that the species he observed differed much more in their habits and in their anatomy than is generally assumed. "In most species there are two sets of neuters, viz., laborers and soldiers; but in some species (*Calotermes*) the laborers, and in others (*Anoplotermes*) the soldiers, are wanting. With respect to these neuters I have come to the same conclusion as that arrived at by Mr. Bates, viz., that, differently from what we see in social Hymenoptera, they are not modified imagoes (sterile females) but modified larvæ, which undergo no further metamorphosis. This accounts for the fact first observed by Lespès, that both the sexes are represented among the sterile (or so-called neuter) Termites. In some species of *Calotermes* the male soldiers may even externally be distinguished from the female ones. I have been able to confirm, in almost all our species, the fact already observed by Mr. Smeathman a century ago, but doubted by most subsequent writers, that in the company of the queen there lives always a king.

"The most interesting fact in the natural history of these curious insects is the existence of two forms of sexual individuals, in some (if not in all) of the species. Besides the winged males and females, which are produced in vast numbers, and which, leaving the termitary in large swarms, may intercross with those produced in other communities, there are wingless males and females which never leave the termitary where they are born, and which replace the winged males or females whenever a community does not find in due time a true king or queen. Once I found a king (of a species of *Eutermes*) living in company with as many as thirty-one such complementary females, as they may be called, instead of with a single legitimate queen." Fritz Müller then goes on to make the following reflection: "Termites would, no doubt, save an extraordinary amount of labor if instead of raising annually myriads of winged males and females, almost all of which (helpless creatures as they are) perish in the time of swarming, without being able to find a new home, they raised solely a few wingless males and females, which, free from danger, might remain in their native termitary; and he who does not admit the paramount importance of intercrossing must, of course, wonder why this latter manner of reproduction (by wingless individuals) has not long since taken the place, through natural selection, of the production of winged males and females. But the wingless individuals would of course have to pair always with their near relatives, whilst by the swarming of the winged Termites a chance is given to them for the intercrossing of individuals not nearly related."

We will now turn to the matter of the internal economy of the termite community. And here it may be said, that we actually know more of the habits of African and Brazilian species than of our own, though the latter is so common in the United States. So far as our own observation goes, the males and females of *Termes flavipes* acquire their wings and 'swarm' in Kentucky during the first week in May, occurring in great numbers under the bark of stumps. They swarm about three or four weeks

later in Massachusetts. I have never seen the flight of such a swarm in the open air, but Dr. Hagen notes an immense swarm of this species at Cambridge, Mass., on the morning of May 19, 1878, forming a dark cloud. He adds that they were accompanied by fifteen different species of birds, some of which so gorged themselves with these insects that they could not close their beaks. This swarm appeared early, as Hagen observes that the white ant usually takes its flight in the middle of June. At the same time or shortly before they begin to fly, many pupæ may be found with the wings in different stages of development.

The most remarkable structures formed by white ants are the famous nests or termitaries of *Termes bellicosus* of the west coast of Africa. These, from their

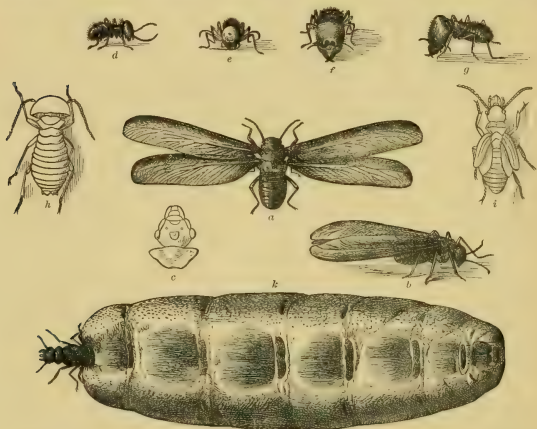


FIG. 210.—White ants. *a*, *b*, *Termes dirus*, male; *c*, head; *d*, *e*, worker; *f*, *g*, soldier. *h*, *T. bellicosus*, worker; *i*, pupa. *k*, *T. regina*, female, the abdomen distended with eggs.

number and great size, appear like the villages of the natives. These white-ant hills are said by Smeathman to be in the form of sugar-loaves, about ten or twelve feet high, and are so solid that an ox can stand upon them. The exterior is one large, dome-like shell, which is much stronger than the inside or habitable part; the latter is divided into a great number of apartments surrounding the royal chamber for the king and queen; these apartments serve as abodes for the young, as well as magazines, which Smeathman "always found well filled with stores and provisions."

In the accompanying figure, *a* and *b* represent the male, *c* the head, *d* and *e* the worker, *f* and *g* the soldier of *Termes dirus*; *h* the worker, *i* the pupa of *T. bellicosus*; and *k* the female of *T. regina* with her abdomen distended with eggs. Winged females of *T. bellicosus* are found flying about at the beginning of the rainy season. After being on the wing for a few hours they descend to the ground, certain of them

being elected by the workers kings and queens of new colonies; those not thus selected soon perish. The workers immediately enclose the king and queen in a small chamber of clay suitable to their size, into which at first they leave but one small entrance, large enough for themselves and the soldiers to go in and out, but too small for the exit of the royal pair.

It is not until this time that the marriage of the royal pair takes place. The queen then lays her eggs, at the rate of sixty a minute, which would amount to eighty thousand in a day. The eggs are taken up by the workers as soon as they are laid and placed by them in a small nursery which they in the meantime have constructed at places four or five feet in a straight line from the royal chamber. Here the young are carefully attended and fed until they are able to shift for themselves, and take their turn in working for the interests of the community.

Of the faithful services rendered by the workers to the queen, Smeathman bears witness, saying, "These faithful subjects never abandon their charge even in the last distress; for whenever I took out the royal chamber, and, as I often did, preserved it for some time in a large glass bowl, all the attendants continued running in one direction around the king and queen with the utmost solicitude, some of them stopping in every circuit at the head of the latter as if to give her something. When they came to the extremity of the abdomen they took the eggs from her and carried them away, and piled them carefully together in some part of the chamber, or in the bowl under or behind any pieces of broken clay which lay most convenient for the purpose."

It appears, from the observations of Mr. H. J. Hubbard on the white ants of Jamaica, that the young are fed upon prepared food which is stored up in the form of very hard and tough rounded masses, evidently composed of comminuted wood, some nests containing many pounds weight of them. Besides these lumps, adds Dr. Hagen, there is prepared for the young white ants another kind of food, probably partaken of by the youngest larvae. Among the eggs occurred a large number of very small, hard, round bodies, which were recognized by Professor Farlow as the sclerotium of a fungus.

SUB-ORDER II.—ODONATA.

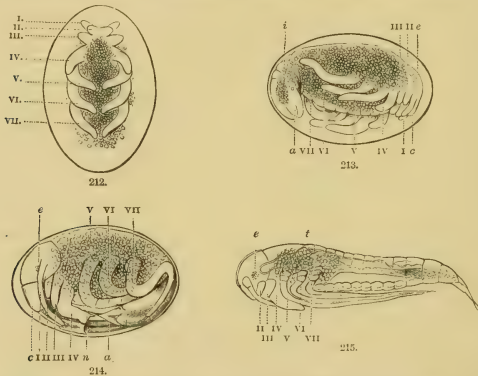
The sub-order Odonata and the family LIBELLULIDÆ are co-extensive. The group comprises the dragon-flies, of which the larger kinds are called devil's darning needles, and sometimes mosquito hawks. Looking at the dragon-flies in the winged or imago state we observe some notable differences which we have not met with in our ascent from the Perlidæ. In the first place the large, spherical thorax has some remarkable features. The prothorax is very small and collar-like, while the pieces which in the Platyptera form broad, flat areas, are in the dragon-flies minute, and the upper part of the thorax is in reality formed of the side pieces which are enormously developed. The dragon-flies literally live on the wing; they never walk, and



FIG. 211.—*Libellula trimaculata*, dragon-fly.

thus the muscles of flight, which are attached to the side-pieces, have a great development; so much so as to give a unique appearance to these creatures.

Moreover the head of dragon-flies is remarkable for the enormous size of the eyes, which in many of them not only completely encircle, but form a large proportion of the head, so that the head appears "all eyes." The mouth-parts, jaws, etc., are constructed much like those of grasshoppers, but the under lip differs in its strangely modified palpi or feelers, which are broad and saucer-like so as to cover the lower part of the face. Add to these characteristics the long slender abdomen, which balances the body during its rapid, headlong flight, and we have an insect with a decided *outré* appearance. None of its contours can be said to be lines of beauty, and the dragon-fly is upon the whole one of the most repulsive of insects, though gaily colored, and decorated with the brightest of trappings and spots. In the popular estimation dragon-



FIGS. 212-215. — Development of a dragon-fly; I, antennæ. II, mandibles. III, maxillæ. IV, labium. V-VII, legs. a, abdomen. c, clypeus. e, eye. i, intestine. n, nerve. t, trachea.

flies hold an unenviable position; but worse qualities are ascribed to them than they really possess. They do a great deal of good in devouring mosquitoes, and other noxious flies and insects, as they are continually hawking about after gnats, etc.

The transformations of the dragon-flies have always attracted interest. They are 'incomplete,' *i. e.*, the larva and pupæ are active, creeping about over the bottom of pools among aquatic plants, and feeding upon other aquatic larvæ.

We will now consider the singular mode of egg-laying practised by these insects, and we will first quote Mr. Uhler's account. In laying her eggs the *Libellula* "alights upon water-plants and, pushing the end of her ovipositor below the surface of the water, glues a bunch of eggs to the submerged stem or leaf. *Libellula auripennis* I have often seen laying eggs, and I think I was not deceived in my observation that she dropped a bunch of eggs into the open ditch while balancing herself just a little way above the surface of the water. I have also seen her settled upon the reeds in

brackish water, with her abdomen submerged in part, and there attaching a cluster of eggs. I feel pretty sure that *L. auripennis* does not always deposit the whole of her eggs at one time, as I have seen her attach a cluster of not more than a dozen small yellow eggs. There must be more than one hundred eggs in one of the large bunches. I have observed females of *Perithemis domitia* on a sunny day late in July hovering over the surface of a pond, dipping the abdomen (the body being in a perpendicular attitude with the wings in rapid motion) lightly into the water, which just covered a piece of floating cow-dung, and then fly off to return again and repeat the operation. Several dragon-flies were coursing over the small pond, and we are inclined to think that two or more dragon-flies pushed their eggs into this same mass of ordure. The dipping motion was the work of an instant; whether one alone or a packet of eggs were deposited at a single dip of the hind-body I could not say, but from the arrangement of the eggs they were probably deposited singly." The eggs of a smaller and more common dragon-fly (*Diplax*) were found by Professor Hyatt early in July (the 2d) attached to the leaves of a submerged sedge. They were dispersed through a long ropy gelatinous mass, about a quarter of an inch thick, which twined about the leaves of the grass. These eggs must have been laid for a week or more, as on the 16th of July large numbers had already hatched. They continued to hatch while in glass jars till the first week of September, those eggs situated in the middle of the gelatinous mass seeming to hatch last; in this way a succession of young dragon-flies were disclosed through the summer. The eggs are oval-cylindrical. The egg-laying habits of the small Agrions and their allies are most singular. These creatures of the air and sunlight, when impelled to deposit their eggs, deliberately enter the water, walk down some submerged stem, and with their ovipositor cut gashes in the stalk into which they push their eggs.

The larvæ of most dragon-flies are rather stout-bodied, sometimes broad and flat, especially the hind-body, and are very active in their habits, constantly foraging after food, creeping about over the bottom, or making their way through thickets of submerged aquatic plants. They can also propel themselves forwards for a distance of several inches by a curious method. The end of the intestine opens for the passage inwards of the water, which fills up the dilated rectum; the walls of the rectum are provided with many small air-tubes, by which the air is extracted from the water and distributed throughout the body. After all the air is extracted from the water the walls of the passage violently contract and force the water out in a powerful stream as if from a syringe, and thus the insect is sent headlong through the water. In the larvæ of the smaller genera of the family, such as *Agrion*, etc., respiration

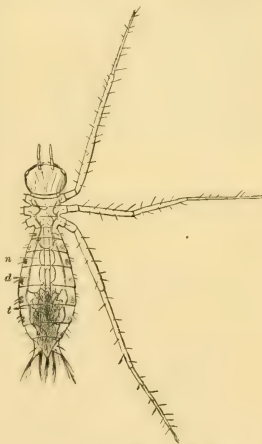


FIG. 216. — Larva of dragon-fly, just hatched.
d, heart. n, nervous cord. t, trachea.

is external, the larvæ breathing by three leaf-like gills containing finely-branching air-tubes.

The most striking peculiarity of the larval dragon-fly is the nature of the labium or under lip. This is greatly enlarged and bent, so that at rest it forms a broad, smooth mask covering the jaws. When any small insect approaches, the array of jaws and accessory jaws is unmasked, the under lip being darted out after the prey. The under

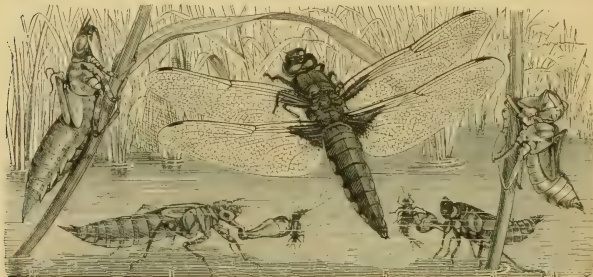


FIG. 217. — Metamorphoses of dragon-flies. 1, larva, and 2, larval skin of *Æschna*; 3, larva, 4, moulting, and 5, adult of *Libellula depressa*.

lip thus serves as a mask, and also as a grappling-iron to seize the victim, as it is armed at the extremity with a pair of hooks, by which the struggling insect is firmly held and irresistibly drawn to the mouth, where it is torn to fragments by the sharp jaws. This structure is well shown in the adjacent figure.

The pupal dragon-fly differs from the larva only in possessing the rudiments of wings, which are like long, slender pads on the back. "When the insect is about to assume the pupa state, the body, having outgrown the larva skin, by a strong muscular effort opens a rent along the back of the thorax, and the insect, having fastened its claws into some object at the bottom of the pool, the pupa gradually works its way out of the larva skin. It is now considerably larger than before. Immediately after this tedious operation its body is soft, but the crust soon hardens. This change, with most species, probably occurs early in summer."



FIG. 218. — Pupa of *Æschna*.

"When about to change into the adult fly the pupa climbs up some plant near the surface of the water. Again its back yawns wide open, and from the rent our dragon-fly slowly emerges. For one hour or more it remains torpid and listless, with its flabby, soft wings remaining motionless. The fluids leave the surface, the crust hardens and dries, rich and varied tints appear, and the dragon-fly rises into its new world of light and sunshine." (Guide to the Study of Insects.)

The Odonata are divided into three groups; the lowest, called *Agrionina*, and represented by the genus *Agrion*, comprises small, slender-bodied, delicate forms,

beautifully marked with metallic green, or blue, while their larvæ have external, leaf-like gills. In *Æschia* and its allies the two pairs of wings are unequal, the abdomen is cylindrical, and the species of large size, while in the *Libellulina* the abdomen is often flattened; most of the dragon-flies belong to this latter group.



FIG. 219. — *Libellula quadrimaculata*. FIG. 220. — *Nannophya bella*. FIG. 221. — *Agrion saucium*, dragon-flies.

The sexes often, as in *Agrion* and *Libellula*, differ greatly in color, the males being bright-colored, while the females are dusky and of one color. Moreover dimorphic forms occur among dragon-flies, there being two sets of females, differing in the venation of the wings, one set resembling the males.

SUB-ORDER III. — EPHEMERINA.

The May-flies, forming the family EPHEMERIDÆ, differ so much from other Pseudoneuroptera that they may properly be referred to a distinct sub-order (Ephemera). These insects are called may-flies because many of them appear upon the wing in the month of May, or early in summer. The name Ephemera is given in allusion to their shortness of life, many of them living in the adult stage only a few hours, or no more than a day, hence they are sometimes called day-flies. They are among the most delicate and fragile of insects, and their motions during flight are exceedingly graceful. Westwood speaks of their elegant flight in swarms (composed, as in the gnats, almost entirely of male insects), in fine afternoons, over or near water, alternately rising and falling, and he states that in this operation the upward flight is produced by the repeated action of the wings; but that in descending, the wings are widely extended, as well as the tails, or caudal filaments. The head is small and rounded, the thorax is spherical, the prothorax being small and collar-like, while the abdomen is long and slender, ending in two or three long, slender filaments. The wings are densely net-



FIG. 222. — *Lachania abnormis*, enlarged.

veined, and the hinder pair are much smaller than the fore; and in certain forms, as the species of *Cloëon* and *Cænix*, the hinder pair are entirely wanting. Returning to the structure of the head: while the eyes are very large in the males, meeting, as in the dragon-flies, on top of the head, the antennæ are also minute, slender, and awl-shaped. The singular condition of development of the mouth-parts indicates that these insects take no food during their ephemeral existence out of the water. The mouth-parts are in an unusually rudimentary condition. We have been unable, in a common Ephemera, to find any traces of mandibles, while the maxillæ are very rudimentary, the palpi being entirely wanting.

The Ephemera, weak as it is individually, maintains itself in the world by means of its prolificacy. Brooks and ponds are richly populated with their young, and through the summer, when they come to maturity and take their flight, these delicate beings appear in immense numbers. They rise from the waters of our great inland lakes, fall a rapid prey to the waves, and are washed ashore, in enormous quantities, their dead bodies forming windrows, comparable in extent with the sea-wrack of oceanic shores. They settle down in dusky dun-colored clouds in the streets of the lake cities, obscuring the street-lamps, and astonishing the passer-by. We may feel some astonishment at the hosts of these winged Ephemeræ when we bear in mind their usefulness in the larva state as food for other insects, Crustacea, and fish. Westwood states that the swarms of one species, with white wings, has been compared to a fall of snow, "whilst in some parts of Europe, where they abound, it is the custom to collect their dead bodies into heaps, and use them for manure. The fishes, at such time, eagerly wait for them; and so great are the numbers which fall into the water, that the fishermen call them manna." They are well known to the angler as excellent bait for trout, and they are a favorite food of the smaller dragon-flies.

The may-flies pair while flying over the surface of the water, and the female drops in the water her minute eggs, which are deposited in two long, cylindrical, yellow masses. The species of *Baëtis* creep down into the water and deposit their eggs in rounded patches on the underside of stones. The larvæ may be known by their long, flat, slender bodies, provided with gills, arranged in pairs along the sides, or upon the back, of the body. These so-called gills are sometimes leaf-like, either simple or with the edges often fringed with filaments, or they are long, narrow pads or lobes, also fringed. In some remarkable cases, as in the singular genus *Batisca*, the gills are covered by broad plate-like expansions of the thorax. In its larval and pupal condition the entire thorax above forms one piece, like the carapace of a shrimp, instead of being divided into three segments. This shield-like plate extends over one half of the abdomen, in the form of a large shield, giving the insect, as Walsh says, "a very crustacean appearance." While in most Ephemera larvæ the ample gills are used in swimming, as well as for breathing, in *Betisca* they are covered over by the shield, and are of no use in locomotion.

A similar larva is that of *Prosopistoma*, which has long been known, but whose life-history has only recently been discovered. Here, as in *Betisca*, the entire thorax and the basal half of the abdomen is covered with a large shield, which conceals the broad gill-sheets.

The Ephemeræ, both in their larval and pupal states, are sometimes carnivorous, preying upon other insects, and their jaws are well developed, sometimes remarkably

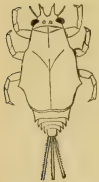


FIG. 223. — Pupa of *Baëtis*.



A swarm of *Ephemera*, May-flies.

so, as in *Ephemera*, *Palingenia*, and *Leptophlebia*, one of the teeth extending in a long, sharp point beyond the head; most of them, however, feed on mud or minute aquatic plants. The habits of the larval *Ephemera* vary somewhat. Some prefer running streams, others inhabit quiet basins or sluggish streams; in these situations they reside in burrows in the mud, under stones, or among grass and weeds, where they may be taken with the water-net in great abundance, and are beautiful objects for the aquarium. It is generally agreed by authors, that in their preparatory state they live for two or three years, — though we doubt if most species live longer than nine or ten months, hatching in summer and acquiring their wings the following spring, — before acquiring wings, so that the whole life of some *Ephemera* may be much longer than that of most insects.

The number of moults, or changes of skin, is unusually great in these insects. The larva of *Heptagenia* has been found by Vayssière to shed its skin eight times before leaving the water, *i. e.* there are nine stages of immaturity. The extreme in the number of stages is seen in *Chiron*, which has been found by Lubbock to moult its skin twenty-one times before assuming the imago state, or twenty times before it leaves the water.

Shortly after the winged insect casts its pupa-skin, it throws off a thin skin, or pellicle; the insect, in this stage, is called the sub-imago, or pseudimago. The best description of the process has been given by Westwood. When in the pupal stage they crawl to the surface, where they cast off their pupa skin, appearing, at first sight, to be fully developed, with the wings extended to their full size. "They then make their way, flying with difficulty, to the shore, where they affix themselves to the trunks of trees, stems of rushes, walls, or even persons standing upon the bank, when they again cast off a very delicate pellicle, in which they had been entirely encased, and which remains, unchanged in form, attached to the objects on which they had stationed themselves. The skin, however, in which the wings had been enclosed, shrivels and curls up into a mass, hanging down at the sides of the thorax. After this process, the wings, disengaged from the outer covering, assume a brighter appearance, and the tails grow to twice their previous length."

Westwood invariably found that the casting off of this pellicle takes place during the night. In some European species the operation of shedding the thin skin takes place immediately after flight, and is so quickly performed that the whole operation is over in three minutes, and the insect takes wing immediately after. Westwood adds, that he has observed, in one instance at least, that the insect remained in the sub-imago state upwards of twenty-four hours.

We will now glance at the principal generic forms of these interesting insects. In *Ephemera* there are three long caudal filaments, of equal length. One of our commonest species, in the northeastern States, is *Ephemera* (*Leptophlebia*) *cupida*. The largest species of the family belong to the genus *Palingenia*, in which the middle caudal filament is shorter than the others, or sometimes absent. It is common in our northern lakes and streams late in the summer.

The genus *Baëtis* has but two caudal threads: near this comes the curious *Baëtisca*, already referred to; then comes *Potamanthus*, which again has three caudal filaments. Fig. 224 represents *P. marginatus*, which we have often captured in Labrador in July. It is also found in



FIG. 224. — *Potamanthus marginatus*.

northern Europe, especially Lapland. In *Cloë* there are sometimes but two wings, the hinder pair wanting; while the species of *Coenïs* never have any hind wings. The most abnormal ephemerid is *Oligoneuria*, in which the wing-veins are very few, and far apart, and the legs are imperfectly developed, and there are three caudal threads. Allied to this is a Cuban form, *Lachlania abnormis*, in which there are but two caudal threads.

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FIG. 225. — *Psocus*.

ORDER IV. — NEUROPTERA.

The genuine Neuroptera are those net-veined insects which have a complete metamorphosis. The larvæ are entirely unlike the adults, as they are long and slender, with more or less cylindrical bodies, some, as the caddis worms and larval forceps flies (*Panorpa*), being much like caterpillars. The pupæ are never active, and are in many cases protected by a cocoon. A neuropterous pupa is a good deal like the chrysalis of a moth, differing, however, besides other characteristics, in the wings and limbs being free and movable, not soldered to the body.

The adult Neuroptera are only net-veined in the Sialids and gauze-winged flies (Hemerobidae), and the cross veins are much less numerous than in the false Neuroptera. There is one feature in which the Neuroptera almost invariably differ from the Pseudo-neuroptera, and this is in the nature of the extremity of the under lip (ligula), which

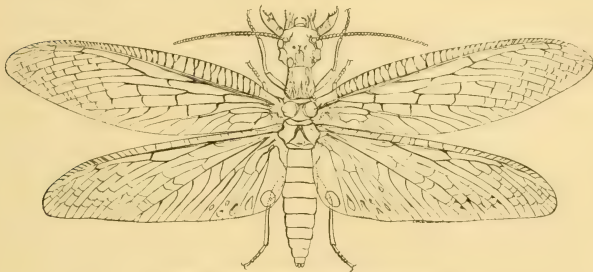


FIG. 226. — *Corydalus cornutus*, horned corydalid, female.

is not cleft at the tip, but is broad and flat. Moreover, the prothorax is often small and collar-like, though large and square in the two lower families. In the higher groups of caddis flies and forceps flies the thorax is more or less rounded, spherical, like that of moths, and the fore wings are in the caddis flies rather smaller than the hinder pair.

The family SIALIDÆ (the members of which are thick and stout, with a large, square prothorax and net-veined wings, and usually aquatic larvæ) is represented by one of the largest and most singular insects in this country; nothing of the sort existing in the Old World. It is the *Corydalus cornutus* of Linnaeus. Though exceedingly formidable and alarming in appearance, it is in reality entirely harmless. Moreover, it flies mostly by night, though we have known one case of its flying in the day-time and alighting on a person's clothes. It is fully two inches in length, while the wings expand a little over six inches, the two pairs being of nearly the same size. An interesting peculiarity of this insect is the remarkable size of the jaws in the male; in the female the jaws are very large, flat, and toothed at the extremity, but in the male they are remarkably long and slender, cylindrical, not toothed, the sharp tips crossing each other. Their only use is evidently for seizing the soft, somewhat yielding body of the

female during the act of pairing; hence, during its short life, the male, at least, probably takes no food.

After pairing, which occurs in the middle of summer, the female deposits her eggs, to the number of about three thousand, in flat, rounded masses, on trees overhanging water, etc. On breaking forth from the egg the young larva readily finds its way into the water, and descends to the bottom. It undergoes six moults before pupal life.

The fully grown larva is as large an insect as is to be found in our streams, and it is a very singular creature. It crawls actively about, seeking smaller aquatic worms and larval insects, which it snaps up and tears to pieces with its large toothed jaws. It can breathe both out of and in the water, since besides a series of spiracles on each side of the body it possesses eight pairs of bushy breathing appendages, or gills, with a long supplementary filament, which it ordinarily uses while in the water. The spiracles come in play late in larval life, as it lives several weeks out of water before seeking its cell, within which to transform into a pupa.

The following account of its metamorphosis is copied from the "American Entomologist."

After it first leaves the water, the larva crawls rapidly about, in the night-time, to find a suitable place for its pupal transformation, usually selecting for this purpose the under surface of a flat board or log, or burrowing under some large stone. In pursuit of this object they sometimes wander almost a hundred feet from the water's edge, and we have known them to crawl up the walls, and on to the roof of a low, one-story frame building, and then tumble accidentally down the chimney, to the great dismay of the good woman of the house. At this period of their existence they are much sought after as fish-bait, having a very tough integument, so that one larva suffices to catch several fish; and they are called by fishermen "crawlers," "dobsons," and sometimes, we hope rarely, "hellgrammites." They can pinch pretty sharply with their strong jaws, though not sufficiently hard to draw blood; and they also use the processes at their tails as prehensile organs to aid them in climbing.



FIG. 227. — Larva of a sialid.

"After it has selected a suitable hiding place, the larva forms a rude cell in the earth, within which it transforms into an inactive pupa, with no mouth to receive food, and no anus to discharge fæces.

It usually leaves the water about the beginning of June, and by the end of that month, or the fore part of July, the winged fly bursts from the shell of the pupa."

A smaller form, though still a large insect and an interesting one, is the *Chauliodes*; it chiefly differs from the foregoing genus in its beautifully pectinated, or feathered feelers, and its more delicate wings. Such is *Chauliodes pectinicornis*, our commonest species. The larva of another species (*C. nastricornis*) is like the hellgrammite, but considerably smaller, and with no caudal filaments; while the last pair of spiracles is on the tips of a pair of contractile filaments.

The genus *Sialis*, which gives its name to the family, comprises a few small species, which inhabit the Old and New Worlds, while the singular genus *Raphidia*, so far from being aquatic, lives under the bark of trees, where it pursues small insects; the species in this country are confined to the Pacific States.

The lace-winged flies, which form the family *HEMEROBIDÆ*, are characterized by a slender body, a small, square prothorax, and net-veined wings, while the larvæ, which

are terrestrial, feed on plant lice. Very useful and entertaining in their habits are the lace-winged flies, whose larvæ are called "aphis-lions," and "ant-lions." The commonest example is the delicate green, golden-eyed, lace-winged fly, so common everywhere, and so offensive in its odor when handled. These delicate, graceful, gauzy-winged gems have as their sole protection an abominable odor, which they leave upon the fingers when rudely handled, and it is doubtless their bad taste which prevents their being snapped up by birds; for one may notice how extremely exposed to the attacks of birds are these insects. The lace-winged flies, when young, do the greatest service to gardeners, from their exemplary habit of devouring plant-lice, or Aphides. The larvæ of different species of *Heimerobius*, which are common among evergreen and other trees, after piercing with their long, sickle-like jaws the bodies of the Aphides, make a thick, loose mantle of the dried skins of their victims.

It is well known that the Aphides congregate in great numbers on the stems or leaves of plants; among them the common golden-eyed, lace-winged fly (*Chrysopa oculata*) lays its eggs. We have observed that the female *Chrysopa* lays between forty and fifty eggs, which are placed upon long, slender stalks, so as to be out of the reach of wandering, predaceous mites, and other egg-eating insects. One *Chrysopa*, which was observed in confinement, laid forty-six eggs; another, whose reproductive powers were evidently impaired, laid eighteen stalks, upon only nine of which were well-developed eggs, the remaining nine being barren stalks, some only half the usual height, while others were provided with the knob, formed of cement, at the end, on which the egg is ordinarily fastened. It is evident that the fly, in depositing an egg, first attaches the stalk to the surface of the leaf, and afterwards forces the egg from her oviduct and attaches it by the mass of cement to the end of the stalk, as in one case an egg was glued to the end of the stalk very much out of centre, the insect's ovipositor not having aimed straight, so to speak, at the mass of cement. The eggs are at first of a pale, delicate green, turning grayish just before the embryo hatches.



FIG. 228. — *Chrysopa* and eggs.

The eggs are laid throughout the summer, so that there is a constant supply of aphis-lions, and the time of embryonic growth is limited, as the young appear in six or seven days from the time the eggs are laid. When the larva is ready to turn to a chrysalis it spins a round cocoon of silk, and two weeks later the winged fly appears.

The species of *Heimerobius* have essentially the same habits as those of *Chrysopa*, but they are smaller, obscurely colored, and less frequently met with, occurring in forests.

Another notable form is *Mantispa*, so-called from its mimicry of the praying insect, or *Mantis*. The neck or prothorax is remarkably long, but most remarkable are its fore-legs, which are very large, and bent, like those of *Mantis*, in the attitude of prayer; but in reality they are admirably adapted for seizing, and retaining in their grasp, other insects.

The metamorphosis of *Mantispa* is of unusual interest, inasmuch as the larva passes through two stages, with quite different habits in each, before spinning its cocoon and assuming the pupa state. Thus far we are acquainted only with the life-history of an European species, *Mantispa styriaca*, which has been worked out by Brauer, an Austrian entomologist of distinction. The rose-red eggs are laid in great numbers, in July, and, like those of *Chrysopa*, are laid on long, slender stalks. The larva hatches in twenty-one days, and spends the winter without taking food. In the succeeding

April the minute larva of the first stage finds its way into the egg-sacs of spiders belonging to the genera *Lycoşa* and *Dolomedes*, biting a curved slit, through which it enters into the sack. By the middle of May the larva is still in the first stage, but



FIG. 229.—*Mantispa interrupta*: the wings not shown in the lower, side view.

surrounded by dead spiders, showing that it is carnivorous, and diets on young spiders. Before the first moult it somewhat resembles a *Campodea*, but after casting its skin it is maggot-like in appearance, with rudimentary limbs, its motions being like those of a larval bee; the short, stumpy legs not capable of use. The head is remarkably small, and retracted under a fold of the thick second segment, and is transversely oval with an eye-speck on each side, each composed of six simple eyes. The jaws (mandibles and maxillæ united) extend straight out, ending in a fine point. On the side are the pointed antennæ, which extend beyond the

jaws; the legs are short, thick, obscurely 3-jointed, and situated far apart on the sides. As in the first stage, the larva lies coiled up among the egg-shells and carcasses of the spiders, winding and turning helplessly along. It reaches a length of 7–10 mm. The insect pupates as in *Chrysopa* and *Myrmeleon*, the larva first spinning a roundish or oval cocoon within the egg-sack of the spider, where it remains about fourteen days before moulting, the pupa maturing under the larval skin. Pupation occurs in the middle of June, and four weeks after the winged insect appears.

In the metamorphosis of *Mantispa* there is thus a hypermetamorphosis, *i. e.*, two larval stages. The first stage is *Campodea*-formed, and the second is caterpillar-shaped. The transformations of *Mantispa* appear to give us the key to the mode in which a metamorphosis in the insects was brought about. The larva, born a *Campodea*-like form, active, with large, long, four-jointed feet, living a sedentary life in the egg-sack of a spider, before the first moult loses the use of its feet, while the antennæ are partly aborted. The fully grown larva is round-bodied, with small, caterpillar-like feet, and a small, round head. Its external appendages retrograding and retarded, acceleration of growth goes on within, and thus the pupal form is perfected while the larva is full-fed and quiescent; hence, as a result the pupal stage became a quiescent one, and by inheritance it gradually became a permanent habit characteristic of Neuroptera, all of which have a complete metamorphosis. This complete metamorphosis has probably been inherited by all the orders of metabolic insects, which possibly originated from Neuroptera-like forms, and the imago represents a highly accelerated stage.



FIG. 230.—Second larva of *Mantispa*.

The Ant-lion has always attracted much general interest, from its singular form and peculiar habits. It is the larva of *Myrmeleon*, and our best known species is *Myrmeleon immutatus*. Its habits have been described, as follows, by Mr. Emerton.

The larva digs a pit-fall, about two inches in diameter and one in depth. In digging its lair the creature begins by making a complete circle, and afterwards throws out the sand from the centre. "In digging it uses its flat head and jaws, which are pushed under several grains of sand and then jerked upwards, throwing their load sometimes as far as six inches, and always far enough to avoid leaving a ridge around the pitfall.

When the pit is finished, it lies entirely concealed except the jaws, which are spread apart horizontally at the bottom. The sloping surface of the pit being as steep as the sand can be piled up, is very easily disturbed, and when an insect ventures over the



FIGS. 231 and 232. — *Myrmeleon immaculatus*, and *M. obsoletus*, adult of ant-lions.

edge the ant-lion is apprized of it by the falling sand. It immediately begins to throw up sand from the bottom, deepening the pit, and so causing the sand to slip down from the sides, and the insect with it. The ant-lion then seizes it with its long jaws, and holds it above its head until the blood is all sucked out, when the bloodless carcass of its victim is cast out of its hole. It then repairs the break in the wall of its pit."

Regarding its habits in confinement, Mr. Emerton gives us the following account:—

"After eating he became more timid, and sometimes would not take a second insect. If, however, several were put into the pit at once, he would bite one after the other until all were killed, before deciding on which to begin. I fed him two or three times a week, usually with house-flies, cutting their wings off and letting him take them in his own way. In October, having occasion to travel some

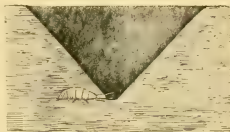


FIG. 233. — Section of pit of ant-lion.

distance, I put him in an ounce bottle half filled with sand, corked him up, and carried him with me in my bag. In about a week I gave him a large house-fly, which he did not catch, not having room enough to make a pitfall. I gave him no more food till the next March. . . . About the first of March, when flies began to be plenty, I commenced to feed him again. He found it rather awkward to catch insects in the bottle, as there was not room enough to make a pitfall, and his inability to move forward made it hard for him to seize an insect, unless he met it directly between his jaws. He soon, however, made pitfalls half an inch in diameter, which answered the purpose. Sometimes he lay on the surface of the sand, with a few grains scattered over his back to conceal him from notice, and his jaws extended on the surface. If a fly was put into the bottle it would circle around it, close to the glass, and usually run over the ant-lion's back. He would jerk up his head, and attempt to seize it, which he seldom succeeded in doing the first time. If he caught a leg or wing he was unable to move nearer, and shorten his hold, and the fly escaped. He would often throw up the sand and try to undermine the fly. He would sometimes work an hour in these ways before the fly would get into a favorable position. I fed him every day or two until May 15th, when he spun a spherical cocoon around him, and remained enclosed until June 25th, a very hot day, when he came partly out, and leaving his pupa skin half in the cocoon appeared as a perfect fly, but did not spread his wings completely."

While the ant-lion's pit found by Mr. Emerton was a solitary one, no others being found, Mr. Birge records his discovery of a large colony of ant-lions in a sheltered, sandy place, under a cliff, in Albany County, New York. In August, 1871, the colony numbered rather more than six hundred individuals, but on July 6, 1872, there were scarcely half that number. Another colony, at a different locality, but in the same county, observed in 1871, consisted of some three hundred members. Mr. Birge remarked that the ant-lion did not, so far as his observation went, "throw up sand to bring down its prey, but throws it up in every direction in order to keep its jaws free



FIG. 234. — *Nemoptera coa* and *Ascalaphus longicornis*.

to seize the insect when it reaches the bottom of the den." Further on he says, in the most crowded portions of the colony "the chief employment of the insects was to throw out the dirt which their active neighbors were depositing on their own premises."

In *Nemoptera coa*, a species from the Mediterranean region of Europe, the forewings are very broad, while the hinder ones are greatly elongate, so that they suggest a pair of oars.

The last type of this family is *Ascalaphus*, which superficially bears a resemblance to a butterfly, since the long, slender antennae end in a conspicuous knob. The head is large and hairy, with large, round eyes, the large wings are often highly tinted with yellow and black spots and bands, while the abdomen is short and thick, like that of

butterflies. In repose the wings are held down on each side, while the abdomen is erect, or nearly so.

Nothing is known of the habits of our American species, which are of very rare occurrence, and of rather dull tints, compared with those of southern Europe, about the shores of the Mediterranean. Even in Europe little is known of the habits, but from what is recorded it appears probable that its transformations are like those of the ant-lion, to which it bears a strong resemblance, though the hind body, or abdomen, is flattened, and much wider, and it is a much larger insect. Westwood tells us that the eggs, when laid, are hedged around by little pales, like a fence, and are so placed that nothing can approach the brood; nor can the young ramble abroad till they have acquired strength to resist the ants and other insect enemies. On the other hand, Koller observed the eggs of *Ascalaphus macaronius* deposited on a stem of grass.

Our third family of true Neuroptera is the PANORPIDÆ. These forms have a slender body, the head with a long beak, the prothorax small, and like a collar; the wings are but slightly net-veined, and the abdomen of the male ends in a forceps. The larvæ are terrestrial, and resemble caterpillars in general appearance. The type of this family is a four-winged fly, not uncommonly seen in damp places in summer, which has a slender body, while the head is remarkably prolonged into a beak, at the end of which are the mouth-parts. The antennæ are filiform, and shorter than the wings, the latter being weak, long, and narrow, with a few cross veins, and more or less spotted. The prothorax is collar-like, and the thorax is rather deep, and somewhat rounded. The species of *Panorpa* are called scorpion-flies, from the large forceps-like apparatus at the end of the abdomen of the males, which resembles the tail, or sting of a scorpion.

These weak, defenceless flies are probably saved from extinction by birds, and other enemies, by emitting a disagreeable odor. For example; when disturbed, the European species (*Panorpa germanica*, or *P. communis*) dart out a long, slender tube towards the disturbing object. Through this tube a little drop of malodorous, whitish fluid is forced, which is undoubtedly repugnant to its enemies. Our common species are *Panorpa rufescens* and *P. debilis*.

Nothing is known of the habits of our species, and we are obliged to recur to the admirable account of Dr. Brauer, of Vienna, concerning the European *Panorpa communis*. Four days after pairing the female lays a few eggs in a mass, situated in a shallow hole, which she bores with her long abdomen in damp earth. In a few days afterwards both males and females die.

The male is polygamous. The eggs are rather large for so small an insect, and are about half a line in length; at first white, and afterwards dark brown. The larva hatches in eight days from the time the eggs are deposited. They are at first one and a half lines long, and grow very rapidly, becoming fully grown in thirty days, then being seven lines in length. The body is thick, fleshy, cylindrical, much like a caterpillar; the segments are full and convex, and beset with brown, horny warts, bearing short bristles. On the last three segments are cylindrical tubercles, bearing long bristles. But the point of most interest, and that which causes them to resemble caterpillars, is that besides the three pairs of jointed, horny feet there are eight pairs of fleshy, ventral, or abdominal feet, which correspond to the abdominal, or prop-legs of lepidopterous larvæ, though no caterpillar is known to possess more than five pairs of



FIG. 235. — *Panorpa rufescens*.

such legs. It should be observed, however, that the abdominal legs in the larval *Panorpa* are quite small and rudimentary.

Moreover, as in caterpillars, there is a large pair of spiracles on the prothoracic segment, but none on the second or third segments; while the fourth to eleventh, behind the head, each have a pair of spiracles. This arrangement of the spiracles, or breathing pores, is identical with that of caterpillars. The head is rounded, and not very large. On the whole, as Brauer observes, "the form of the larva is caterpillar-like." In confinement the larva digs a horseshoe-shaped passage, an inch deep, in damp earth, and lives on putrid meat and bread. Brauer also found one larva in a deep mouse's nest, situated between decaying roots; another under a stone, in a damp, though nearly dry, forest brook; and a third time, one was found under a moss-grown, mouldering stump, with ants, not feeding on them, but rather sharing with them their food, dead animals. In order to pupate, the larva makes an oval cavity in a lump of earth, and buries itself deep in the ground. As a rule the larvæ are sluggish, but can, if pursued, creep rapidly. The larvæ remain in their holes from ten days to three weeks before casting the larval skin, and after remaining in the pupa state fourteen days transform into the final, or imago state.

The life-history of *Bittacus* possesses similar interest. This insect is like *Panorpa*, but the male has no forceps, and in form, with its slender body and long legs, strikingly resembles a *Tipula*, or daddy-long-legs fly, except that it has four instead of two wings. The imagines, or adult flies, live in a sort of chamber, covered in by leaves, grasses, nettles, etc., forming an airy abode, or vivarium. Here they feed on such flies as enter their habitation. The flies die after laying their eggs in the soil and the earth at the bottom of the chamber dries up, but in the following April, when the soil is again wet by the spring rains, the larvæ hatch out. And now a remarkable fact has been noticed by Brauer. He has observed that if the marshy or wet ground, where the female *Bittacæ* customarily lay their eggs, does not dry up, no females appear until the second year following; so that the eggs lie over unhatched two years. The first condition of their hatching is a complete drying of the earth in which the eggs lie; the second condition is a succeeding thorough wetting of the ground in spring. If the ground remains dry from want of snow in the winter, or of rain in the spring, and there follows in the next summer a very thorough wetting of the soil, then the time of appearance of the adult will be retarded three or four months. This is quite analogous to the case of the eggs of *Phyllopod* crustacea, which will remain unhatched for several years if deposited in mud which becomes dry.

The larva of *Bittacus*, unlike those of *Panorpa* and *Boreas*, does not bore into the earth, but lives on top of the ground under leaves, or remains secreted under a clod; in confinement it will live for several weeks if fed with raw meat.

The larvæ have, like those of *Panorpa*, a remarkable resemblance to caterpillars, especially certain silk-worms, or caterpillars of butterflies, as well as to saw-fly larvæ, such as certain species of *Selandria*. Unlike the young of *Panorpa*, the larva of *Bittacus* is protected by two rows of dorsal spiny tubercles which end in long stiff filaments, and which extend from behind the head to the tail. They also have, besides the six thoracic legs, a pair of small two-jointed prop-legs on each abdominal segment, or eight pairs in all, and are thus like the larvæ of certain saw-flies (*Lophyrus*). From their reddish-gray color, and the resemblance of the hairs on their back to particles of earth and bits of plants, they are hard to detect, and are thus easily overlooked by birds and other enemies. Moreover, at the least disturbance they assume an erect

position, throwing the body into the shape of an S, or they roll up spirally like a saw-fly larva, and fall into the cracks in the ground. In this position they are like a ball bristling with spines, and are on all sides inaccessible to the attacks of smaller enemies, while reminding one of a hedgehog or porcupine among the higher animals.

On approaching the time of entering the chrysalis state they bury themselves in the earth one or two inches, and, hollowing it out by the spiral motions of the body, form an oval hole. In this little cell the larva changes, its body becoming shorter, thicker, paler, indeed almost white, while the spine-like appendages become flabby, and lie on the side of the body instead of standing erect; meanwhile the larva, like most caterpillars, keeps turning on its longitudinal axis. After a period of ten days it casts the larva skin and appears as a slender white pupa, and fourteen days later the imago appears.

A still more remarkable insect is the Snow Insect or *Boreus*. It is a smaller insect than the foregoing. In the males the wings are very rudimentary, being about half as long as the abdomen, and narrow and stiff like a style, being entirely useless for flight. The female is entirely wingless, and is provided with a large sabre-like ovipositor. The skin is dark, with bronze tints, and altogether it is a remarkable insect. Moreover its habits are singular. It occurs in moss, and though a rare insect in general



FIG. 236. — Pupa of *Boreus*, snow insect, enlarged.

is found in considerable abundance when it does occur, leaping about on the snow. We have in the northern States two species, both described from New York by Dr. Fitch. *Boreus nivorius* is about one-seventh of an inch long, and is reddish, with a bronze tinge, while *B. brunnalis* is entirely brassy black, and is smaller than the other species. *Boreus californicus* was found near Fort Bidwell in northern California about the middle of December, when they were observed walking on the snow in the morning, disappearing when the sun shone brightly at noon.

In the PHRYGANEIDÆ or caddis flies the body is slender, the thorax rounded. There are no jaws in the adults, which closely resemble some of the moths. The larvæ are aquatic, and live in cases or tubes formed from the surrounding materials. The members of this family are quite unlike any other Neuroptera, and form a sub-order (Trichoptera) by themselves, though the *Panorpide* approach them in some important respects, and serve as connecting links between the present and the other families of Neuroptera. The larvæ of the Phryganeidæ are called Case Worms or Caddis Worms, and the imagines are called Caddis Flies.

The bodies of the caddis flies are cylindrical and have much the same shape as that of a moth, the head being small and rounded, the thorax spherical (owing chiefly to the small collar-like prothorax). Moreover the jaws are either rudimentary or wanting, not being used in adult life, while the wings are shaped like those of a small moth, being folded roof-like on their back, and the venation or veins of the wings resemble those of the Lepidoptera, the short transverse veins being few in number. A number of species of the smaller caddis flies would be easily mistaken for moths, and owing to the close resemblance in nearly all the parts of the body to the Lepidoptera it has been suggested that Lepidoptera have either descended from the caddis flies or that the two groups have had a common origin.

The caddis flies are very common, flying about damp places and brooks, sometimes in swarms; they are usually dull-colored, but a few species are beautifully colored; the species of *Setodes*, for example, are usually snow-white.

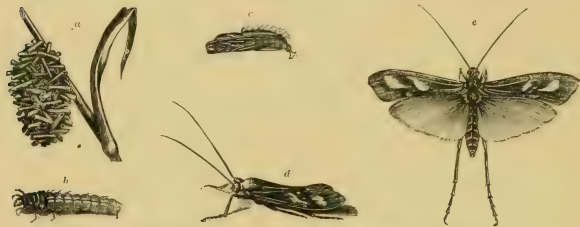


FIG. 237.—*Linnophilus rhombicus*, caddis fly; a, case; b, larva; c, pupa; d and e, adult.

The transformations of the caddis flies are interesting. The eggs are deposited in a double gelatinous green mass, which is attached to the surface of some aquatic plant. Westwood says that the female of *Phryganea grandis* has been observed to creep down the stems of aquatic plants under the water, very nearly a foot deep, for the purpose of laying its eggs. On the other hand, according to McLachlan, the egg-masses, probably of *Halesus*, are sometimes deposited on leaves of trees far from water.

With one known exception, which lives in moss on land, the larvæ of all the caddis flies live at the bottom of ponds and streams. They are all protected by some sort of a case; hence their name, case-worms. There is no end to the variety of form in these cases, and the material of which they are constructed. The accompanying illustrations will serve to represent a few characteristic forms.

Certain caddis worms roll up leaves, cutting them properly so as to roll up with ease, or they sew them together by spinning silken threads from their mouth, attaching to their case large irregular bits of leaves; others attach deserted or "dead" snail shells, or bits of gravel, coarse or very fine, or sand; and others, living in mill streams, cover their cases with coarse sawdust. The cases are usually straight, sometimes curved like a horn, while that of *Helicopsyche* is wound in a spiral like a snail shell.



FIG. 238.—Larva and case of *Linnophilus subpunctulatus*.

More is actually known about the case-worms of southern Brazil than those of North America, owing to the observations of Fritz Müller, who resides in that country, but as there are undoubtedly many similar species in North America we will refer at some length to the different Brazilian forms. Of a genus (*Tetracentron*) allied to *Leptocerus*, and whose imago is remarkable for having gills, one species uses hollow sticks for its case. Of certain forms allied to *Rhyacophilus* one lives, almost without any case, between the tangled stems of water-plants; the anterior legs of the larva are armed with curious, powerful forceps; the cocoon of the pupa is not protected by a regular case. Smaller species of an allied genus build



FIG. 239.—Larva of *Leptocerus*.

portable cases, agreeing with those of most of the "Hydroptilidæ" in not showing any difference between the two extremities; in one of them the water gains access by a small, upright, cylindrical chimney in the middle of the case, in another by small openings along the dorsal side. The group of Hydroptilidæ are divided roughly into six genera, with cases of the following form:—

1. Cases resembling those of the European (and probably North American) species, either naked or covered with fine sand, diatoms, etc, more or less compressed, and with a slit at each end. 2. Very minute, nearly cylindrical, coriaceous, brown tubes covered with fine sand, fixed by either end to the underside of stones, and generally showing two adhesive disks at the anterior, and one on the posterior end. 3. *Diadus*. Strongly compressed oval cases, elegantly covered by diatoms, with a narrow slit at each end, and with two (or sometimes three) cylindrical chimneys for access of water.



FIG. 240. — Different forms of caddis worm cases.

4. In *Lagenopsyche* the cases resemble a bottle with the bottom cut away and the lower part compressed until only a slit is visible, the neck representing the mouth-end by which it is held in an upright position. Before transformation to a pupa the case is fastened by disks of silk, and the larva then turns itself in the case so as to keep the head of the pupa uppermost. 5. Cases of younger larvæ of *Rhyacopsyche* are brown, coriaceous, nearly cylindrical, widening in the middle. From one end proceeds a silken thread, sometimes more than twice the length of the case, by which it is fastened to stones so as to prevent its being swept away by the rivulets in which it lives. Before transformation to the pupa the thread is much shortened, so as to sustain the case in an upright position.

The case of *Helicopsyche* merits attention from its resemblance to certain fresh water shells, such as *Valvata*, for which it has been mistaken even by conchologists of experience. The larvæ of *Helicopsyche glabra* may be found in lakes in the north-

eastern States. The case is like a *Helix* or *Valega* shell, usually very regular in form, though the umbilicus varies in size. It is composed of fine grains of sand so arranged that the outer surface is smooth. It is closed during the pupal stage by a dense, silken, concave, suborbicular operculum, with concentric lines, rounded on one side, and but slightly convex on the other, with a slightly curved slit for the passage of water situated on the less convex side, each side of the slit being provided with slender straight teeth which nearly touch each other, thus forming an imperfect grate. The larva does not spin a cocoon, but after spinning its operculum lies in its case with its head just behind it. Though the body of the larva is curved it is not spirally so, as would be inferred from the shape of its case. It is a quarter of an inch long. The adult or imago of the species of this genus is not very dissimilar to other small caddis flies.



FIG. 241. — Case of *Helicopsyche glabra*.

The larvæ of the Phryganeidæ are, in general, cylindrical, and bear a general resemblance to caterpillars, except that they possess only six pairs of feet—the thoracic ones. Living constantly in the water and never leaving it, they breathe by so-called gills, by which they are enabled to extract the air from the water. The gills are long, slender filaments containing an air-tube or trachea, which branches off from the main tube. The larvæ are mostly carnivorous, living on Entomostraca, so far as we have observed, though they may at times eat decaying vegetable matter. When about to pupate they close up the mouth of the case with a grating, or, as in the cases of *Helicopsyche*, by a dense, silken lid with a single slit, and in some instances spin a slight, thin, silken cocoon, within which the pupa state is passed. Our large *Neuronia semifasciata* transforms to a pupa in the spring, the larva passing the winter in its case. Most of the smaller caddis flies appear in July.



FIG. 242. — *Neuronia semifasciata*.

A. S. PACKARD, JR.

ORDER V. — ORTHOPTERA.

The insects comprising this order were first recognized as different from all the other Hexapoda by De Geer in 1773, who gave to the group the name *Dermaptera*, from their semi-membraneous anterior wings or elytra. Linné placed them with the Hemiptera, and Geoffroy united them with the Coleoptera. Olivier, however, was the first to propose for them the name *Orthoptères* in 1789, but the Latin form did not appear until 1806, when Latreille used the term in *Sommini's Buffon*. The name *Orthoptera* (*orthos*, straight; *pteron*, wing) was given to the order, from the character of the front wings, which are straight, usually narrow, pergumaceous or parchment-like, thickly veined, and overlapping at the tips when closed. The hind-wings are membraneous, with the veins quite straight. They fold up like a fan.

As an order the Orthoptera have never been as satisfactorily restricted as have been some of the other groups. From time to time it has been made the provisional resting-place for various small but comprehensive families that appeared to belong to none of the other orders.

One of the latest systems of classification is that by Dr. A. S. Packard, Jr., who, in an article on the arrangement of hexapodous insects into orders and sub-orders, proposes for a certain group the name of *Phyloptera*, under which he places as of equal rank the *Dermaptera*, *Orthoptera*, *Pseudoneuroptera*, and *Neuroptera* as sub-orders. In this article he shows the necessity for such a change, and bases his views upon the most recent researches in the embryology and development of insects.

The order *Orthoptera*, as restricted and generally accepted by entomologists, and as we shall treat of it here, contains but the following families, all of which



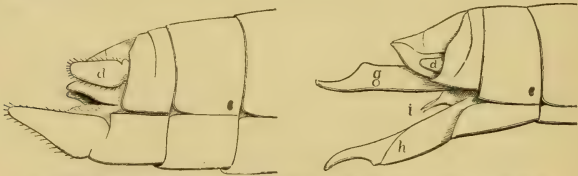
FIG. 243. — Mole crickets.

are terrestrial, with, perhaps, a single exception among the *Phasmidae*: the *Blattidae*, or cockroaches; the *Mantidae*, or rear-horses; the *Phasmidae*, or walking-sticks; the *Gryllidae*, or crickets; the *Locustidae*, or grasshoppers and katydids, and the *Acrididae*, or locusts.

The transformations of orthopterous insects are incomplete, *i. e.*, the young when first hatched differ but very little from the mature insect except in size and in the absence of wings or rudiments of these appendages. There is no state of quiescence as among those insects which undergo complete metamorphosis, the nymph or pupa being quite as active as the imago, and differing from it chiefly in possessing the wings and genitalia in a rudimentary state. The genitalia are, however, sufficiently developed in some instances to permit of coition. The number of moults varies in different groups as well as in the individuals of a species, some undergoing as many as six, while others pass through only three or four. It is generally the case that those species in which

the wings are entirely wanting or in which they are only in a rudimentary condition pass through fewer moults than those possessing full wings. Among many of those forms that have the wings rudimentary it is sometimes quite difficult to distinguish the pupa from the imago. In such cases a safe criterion will be found in the presence or absence of articulation in these appendages. Another and unerring criterion by which the pupa and imago of such species may be distinguished will be found in the position of the wings. The elytra of the pupa are thrown back and twisted around so that the surfaces and margins are precisely reversed when closed as compared with the imago or perfect state. That which is to be the inner surface in the imago is the outer surface in the pupa; the costal margin which is inferior in the imago is the upper or anterior margin in the pupa; the apical veins which curve upward in the former curve downward in the latter. This peculiar arrangement, in connection with the others mentioned, will enable anyone to determine whether a short-winged specimen is a pupa or a mature insect.

The chief characters used in the classification of orthopterous insects are the genitalia, the mouth-parts and the antennæ; though other characters are largely used, as position and form of the eyes, form and comparative length of wings and legs, shape of the head, thorax, and general contour of the whole insect. The cerci



FIGS. 244 AND 245. — End of abdomen of male and female locust (*Aceridium*); *c*, cerci; *g* *h*, ovipositor; *i*, egg guide.

and ovipositor have, however, become recognized within the past few years as the most reliable characters by which species and even genera can be recognized. Especially is this true among the Acrididæ or locusts, where neither size, color, nor the presence or absence of well-developed wings signify specific differences. The sexual organs are most characteristic in the male in some of the families; those of the female most so in others; while in still others these organs in both sexes are of equal importance for classificatory purposes.

The mouth-parts of the Orthoptera, although varying somewhat among the different families, are essentially the same. All the representatives of the order have these parts admirably fitted for biting and gnawing the substances upon which they feed. There are three pairs of these appendages. The true jaws or mandibles are single-jointed, broad, short, and solid, with a toothed cutting and grinding edge. Behind the mandibles are the maxillæ, which are accessory jaws, and serve to hold and arrange the food to be ground by the true jaws. The floor of the mouth is formed by the labium which in reality is composed of a second pair of maxillæ, soldered together in the middle. Both the maxillæ and the labium are furnished with a pair of jointed feelers which also aid in the process of feeding. In front of all these hangs the labrum or lip, a loose flap that covers the jaws like a curtain when they are closed.

The head in this order, with but a single exception, is perpendicular; it is quite large and full between and above the eyes, and is generally partly sunken into the prothorax. The antennæ are generally quite long and thread-like, and are composed of an indefinite number of joints. There are, however, some exceptions to this rule. The legs are well developed in all, and by their form the order has been separated into five sections; viz.: Ambulatoria or walkers, Cursoria or runners, Raptatoria or graspers, Saltatoria or jumpers, and Fossoria or burrowers. In each of these sections the legs are modified to the uses indicated by the names, and furnish a character by which any individual can be assigned to its proper place at a glance. The legs also vary very much in their comparative length and robustness, and thereby greatly aid in the definition of the smaller divisions. The species of Orthoptera are spread over the entire surface of the earth, but are most numerous in the countries lying within and adjoining the tropics. Here the herbivorous species are found during both day and night amongst the trees and other vegetation; while the carnivorous species find abundant lurking-places in which they await the coming of their prey. The Orthoptera comprise some of the largest of the class of insects, and in the tropics assume remarkable forms. The Saltatorial Orthoptera are among insects what the Passeres are among birds. They are the chief insect choristers, and during late summer and autumn cause wood and meadow to ring with their merry and chirping stridulations.

The Orthoptera are among the first forms of insect life that appeared upon our globe. In upper Devonian times a few low and synthetic forms lived amid the vegetation characteristic of that period. In the carboniferous era, when large tracts upon the earth's surface were clothed with dense jungles of tropical vegetation, the representatives of this order became common. In the tertiary period when insect life had become exceedingly abundant, the remains of Orthoptera are found in the greatest numbers. In Europe, where considerable attention has been paid to the study of fossil insects, the number of Orthoptera found is comparatively large. In this country, however, where beds of fossil insects are equally common, comparatively few species have yet been described. The fossil insects found in the tertiary beds of the Rocky Mountain region indicate a tropical relationship to a remarkable degree; and there can be little doubt that the faunal elements of tropical America of to-day entered into the insect life of the central United States in tertiary times. Of these ancient Orthoptera various species of cockroaches and earwigs figure most conspicuously, and represent by far the greatest number of species. Mr. S. H. Scudder, to whom we are indebted for his studies of fossil insects in North America, describes a cricket very similar to our common striped field cricket (*Nemobius vittatus*) under the name *Nemobius tertarius*, from the Green River shales. He also refers to several species belonging to the Locustidæ that were taken from the tertiary shale at different localities in the Rocky Mountain region. Some of the leading localities for fossil insects in this country are as follows: Morris, Ill.; the coal measures of New Brunswick and Nova Scotia; Florissant and White River in Colorado; Green River in Wyoming; Hodge's Pass and Bear Lake in Idaho, and the Tertiary beds of the Nicola and Similkameen rivers in British Columbia. Those of Europe are distributed pretty evenly over the continent, though the most perfect remains have thus far been found in Prussia.

Some of the species comprised in the family of the Cockroaches (BLATTIDÆ) are among the commonest and at the same time the most disgusting of the insect tribe. They are unpleasant to look upon, and offensive to our sense of smell on account of their fetid odor, while they excite our antipathy because of the waste and destruction

they cause. The Blattidæ have received all sorts of popular names, but they are best known as "black-beetles" and cockroaches. Their colors, as a rule, are various shades of dull brown and black, which agree well with their nocturnal habits and the dark haunts they frequent. The body of most species is comparatively large, broad, and flat, and is covered by a very flexible, leathery integument. In some genera the head is almost, while in others it is entirely, concealed beneath the prothorax. The antennæ are very long and thread-like; the feet and limbs are strong and spined, and admirably adapted for running as well as for crawling into narrow cracks and crevices—a habit belonging in a greater or less degree to all the species of the family. During the day-time we see very little of these insects, and become surprised by their sudden appearance at nightfall. This, however, is owing to their nocturnal habits and their trait of hiding themselves away, in which they are materially aided by their compressible skins and the flatness of their bodies, which allow them to squeeze into very narrow places.

The species of Blattidæ, on account of their mode of life, are the most widely distributed of all Orthoptera, and are exceedingly common in some localities. This is especially the case in seaport towns, and on board of ocean steamers, where, favored by the warmth from the engines and the prevailing dampness, they thrive and multiply amazingly. It is therefore an absolute necessity that all goods to be transported from one country to another be well packed in order to be secure against injury from these insects. They have become generally distributed over the entire face of the globe wherever navigation has extended, and have, in fact, very generally followed man. We may rejoice that these cosmopolitan species are so few when we reflect upon the great amount of injury caused by each. Besides these wide-spread and generally-known species, there are numerous other representatives of the family that we find in the woods under bark of trees, in old and rotten logs, and under stones and all sorts of *débris*. This family is most numerous within the tropics, where many of the species are of great size, but do not differ greatly in habit from those living in our woods.



FIG. 246.—Egg cases of a cockroach, *Periplaneta orientalis*: natural size above.

The principal characters used in the classification of the Blattidæ are the form of the prothorax, the limbs, the terminal plate of the abdomen, and the cerci. The relative position of the head also aids materially, while the presence or abbreviation of the wings is likewise significant. The eggs of cockroaches are all laid at once, and encased in a purse-like pod, the form of which varies among the different genera. The operation of egg-laying with these insects, it is claimed, requires many days. The oötheca, as these egg-cases are called, contains a double row of eggs that are placed upon either side of a slit or opening which extends the entire length of the pod. The color of this oötheca when first protruded from the body is almost white, but with time it generally assumes the color of the species to which it belongs. The female

cockroach carries the egg-case about with her until the young are ready to emerge, when it is dropped. Some writers claim that the mother assists the young to escape. These egg-pods are composed of the same elastic material that forms the outside covering of the insects themselves, and when the young escape they close again, leaving the empty shells lying about on the ground. When first born the young cockroaches are perfectly white, and are brooded over by their mother in a similar manner to the brooding of the earwig already alluded to. The accompanying figure represents the oötheca of *Periplaneta orientalis*, natural size, and magnified. The number of moults suffered during growth varies from four to six; and immediately after each moult the insect is quite white, to which fact the numerous reports of albino cockroaches must for the most part be attributed.

The Blattidae as a rule are omnivorous, and consume everything which can possibly be eaten that comes in their way. Nothing comes amiss to them, and they inflict great losses upon merchants as well as upon householders. Imagine the disgust of a cook on board a vessel when, upon opening a box that should contain victuals, he finds

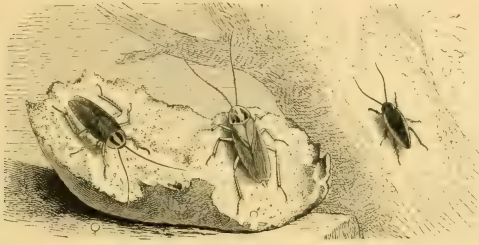


FIG. 247. — *Ectobia germanica*, and *E. lapponica*, cockroaches.

in their stead a living mass of these creatures! On long voyages such is very apt to be the case.

The smallest of these cosmopolitan species is the German Cockroach, *Ectobia germanica*, which is here figured in conjunction with *Ectobia lapponica*, a small species from Lapland. This little roach is of a rather light color, and has two longitudinal dark stripes upon its prothorax. It is chiefly found in houses, and especially about the kitchen, where it lurks in some dark corner till the coming of night when it sallies forth seeking what it may devour. This species is very common in houses in and about all the large cities of New England, where it is called the "Croton bug." Although an almost universal feeder it prefers wheat-bread to all other articles of diet. It is therefore a very common and troublesome pest about bake-shops, where it lurks about the ovens and the dough-trough, and, notwithstanding the utmost care on the part of the baker, sometimes becomes incorporated with the dough and baked in the loaf. It also causes serious damage to libraries, having a special fondness for cloth-bound books, the covers of which it gnaws and renders unsightly. Leather-bound books it does not touch. The use of good pyrethrum powder on the book-shelves is the best remedy for this difficulty.

A second and much larger species is the Oriental Cockroach or "black beetle," *Periplaneta orientalis*, which sometimes appears about meal bags, after dark, in badly infested houses. This insect is very dark brown, or almost black, and has the wings shorter than the body in the male, and only rudimental in the female. It frequents chimney-corners and sinks, and only comes forth after nightfall. The species is said to moult six times before maturing.



FIG. 248. — *Periplaneta orientalis*, "black beetle."

The remedies recommended for the preceding species are applicable to this one; for while the pyrethrum does not invariably kill, it renders them stupid and helpless, so that they may be swept up and destroyed. Powdered borax well sprinkled about their haunts will drive them away, and is said to kill them if mixed with powdered white sugar. A simple and effective roach trap, commonly used in England, is a dish or soup plate half filled with stale beer. This is set upon the floor with thin sticks of kindling wood placed round it like scaling ladders, up which the roaches climb into the alluring beverage.

The two roaches just mentioned seldom swarm simultaneously in the same house, and this fact is generally believed to be due to their feeding on one another. Indeed, the omnivorous habits of the *Periplaneta orientalis* are some compensation for its annoyances. It is not only a great scavenger, keeping pantry and kitchen corners clean and wholesome, but it has the very commendable habit of feeding on that far more obnoxious household pest, the bed-bug, so that the encouragement of the "black beetles" may sometimes be desirable.

Our American Cockroach, *Periplaneta americana*, is somewhat larger than the oriental species, is lighter brown, and has the wings well developed in both sexes. It also frequents houses as do those already described, but prefers to linger about water-pipes and sewers, and is the species most frequently seen among the cargoes of vessels. It is also very numerous in greenhouses where it breeds in great numbers, and does considerable injury to the various plants upon which it feeds. We have observed that it is unusually fond of the foliage of the cinchona plant.

Platanodes pennsylvanicus is a common species in the woods, where it is found under stones and old logs. It also frequently enters houses after dark in midsummer. In California a species of cockroach (apparently an undescribed species of the genus *Heterogamius*) is sometimes found in which the female is wingless, and burrows in the sand, while the male is furnished with long wings and flies about after nightfall, when it is sometimes attracted by lights and enters houses. Similar species are found in southern Europe and northern Africa. Among the large species inhabiting tropical countries there are many wingless forms which bear a strong resemblance to some of the crustaceans, and which also frequent similar localities.

There are numerous other forms of Blattidae that we might mention as being of interest, but as they are all local in their distribution, and are chiefly confined to countries lying within the tropics, we will pass them over. Mr. Scudder has described several species of these insects from the coal-measures of North America, and one from the tertiary beds of Colorado, while there are quite a number of species described from the coal-measures of Europe. It is difficult to give an accurate estimate of the number of species belonging to this family on account of the extremely local distribution of many of the forms, and also on account of the Blattidae having

been sorely neglected by entomologists. The latest synopsis, published by the British museum, enumerates about nine hundred species.

The MANTIDÆ is the only family of the Orthoptera in which all the members are carnivorous. It is also separated from all the other families by the peculiar structure of the front pair of legs, which are constructed for grasping. The species, as a rule, are large, and, like the Phasmodæ, often bear a striking resemblance to various leaves and twigs upon which they sit while waiting for their prey. The Mantide have become popularly known under a variety of names, such as Rear-horses, Race-horses, Praying-insects and Soothsayers, all of which have originated from the peculiar positions assumed by them at different times, especially when waiting for their prey.

The movements of the Mantide are sluggish; their colors are variable; they have long and linear bodies; and in some species the wings are broad and leaf-like. The head is triangular in form, perpendicular, and furnished with sharp but small jaws. The eyes are very large and prominent, and between them are situated the rather short and bristle-like antennæ and three ocelli. The front legs, which are the chief characteristic of the family, are large, strong, and furnished with numerous sharp spines; they are mostly carried in a folded position, and but little used in walking, their true use being that of seizing and holding the insects upon which they feed. The males are more slender and more active than the females, their narrower and longer wings permitting more ready flight. In watching and seizing their prey their motions are wary and stealthy until the final stroke of capture, and there are few more amusing sights than that of one of these creatures silently swaying from side to side, or stealthily moving one limb after another, the head with its prominent eyes turning and watching every motion of the coveted animal meanwhile. The eggs are laid in clusters upon twigs and encased in a flattened ovate case or oötheca. This oötheca is composed of hardened silk, in which characteristic it differs from that of the female cockroach. This peculiar habit of encasing the eggs within a single receptacle would seem to indicate a common origin and the close relationship of the two families.

The young mantis is long and linear, and has the habit of curving up the end of the body and throwing back the head and neck. It comes into the world encased in a thin and delicate pellicle (amnion) which is soon cast off and eaten. The young mantes at once display their voracity by attacking one another. They are the counterpart of the fully matured insect in respect to their mode of life, and what is true of one species is also true of all the others.

The Mantide are nocturnal to a certain degree, especially in their movements and flights, which are mostly performed after sunset. The female, although possessing pretty well developed wings, does not fly. The wings are used, however, in easing herself from a higher to a lower elevation, also when in battle with one of her own kind, or when pouncing upon her prey, at which time she hoists them very much as does a swan when irritated. These insects in some localities have gained the popular reputation of being very meek and reverential, and on this account have received the name of **Praying Mantes**.



FIG. 249. — Egg capsules of *Phasmodontis carolina*.

They are bloodthirsty creatures, and are forever quarrelling and at enmity among themselves, as well as with all other insects. Many a fierce battle is fought by the males in which neither eye nor limb is spared, and in which the winner ends by making a repast off the body of the vanquished. They are so void of feeling that the male (the female being the strongest and most voracious) risks his life in courting, and usually succeeds only by slyly and suddenly surprising his mate, who, after accepting his embrace, often coolly seizes and devours him. So tenaciously do these insects fight that they will continue without cessation or inconvenience for some minutes after the loss of their heads. We have seen a female, decapitated and with her body partly eaten, slip away from another that was devouring her, and for over an hour afterwards fight as tenaciously and with as much *nonchalance* as though nothing had happened.

The most common representative of the family in the United States is *Phasmomantis carolina*. The eggs of this species are laid in a packet about an inch in length,



FIG. 250. — *Phasmomantis carolina*, praying mantis.

and attached to twigs and leaf-stalks. The species is quite common through various portions of the South and Southwest. Its food consists mainly of flies, though it is a most voracious cannibal and will devour its own kind as well as any other insect that comes within its grasp. It has been known to attack butterflies, grasshoppers, and caterpillars of various kinds, and in one instance a single female devoured eleven Colorado potato-beetles during one night, leaving only the wing cases and parts of the legs. It disdains all dead food, and never makes chase for the living, but warily, patiently, and motionless it watches till its victim is within reach of its fore-arms, and then clutches it with a sudden and rapid motion. The newly-hatched larva is light yellowish-brown, but after the second moult, many of them become green. This last color is retained by most of the females, while the males, at maturity, are more often gray.

We know with what fear the hawk is regarded by the great majority of small birds, but that at the same time the common bee-martin defies, and even tantalizes and drives it off. In like manner the mantis, which must be the dread of most flies, is defied by certain parasitic species belonging to the genera *Tachina* and *Sarcophaga*, and we have found no less than nine maggots in the body of a female mantis, which must have

hatched from eggs that had been deposited on her body by one of these flies. The eggs of the mantis are at times infested and destroyed by the singular-looking hymenopterous parasite, *Prionurus pachynurus*, with large and serrate hind femora. A second species found in the United States, is *Mantis missouriensis*, a slender species in which the wings are gray and as long or longer than the body. It is found in the Missouri valley, where it lives among grasses and low vegetation. This insect bears a slight



FIG. 251. — *Empusa ptyopurata*, rear-horses.

resemblance to *Empusa pauperata*, a slender species found in the maritime Alps of Europe, and having somewhat similar habits. This latter insect, however, is very handsomely colored. Its body is decorated with a mixture of most delicate gray, green, white, and violet tints, and the wings of the adult are of a clear sea-green color, the borders and nervures being lilac.

The *Empusa* have a long leaf-like projection on their heads, short antennæ, a very thin thorax, and their legs are ornamented with curious leaf-like expansions. There is also a third and undescribed species of mantis found on the sandy plains along the

eastern slopes of the Rocky Mountains. This is a still smaller insect than the preceding, is wingless and rather stout-bodied. It lives entirely on the ground, which it resembles very closely in color, and is very active, running with as great rapidity as do the various species of tiger-beetles that are to be met with in similar localities.

The commonest species in Europe is the *Mantis religiosa*. In Buenos Ayres *Mantis argentina* is said to seize and eat small birds.

The PHASMIDÆ, popularly known as spectres, walking-leaves and walking-sticks, are the most bizarre of the Orthoptera. They are sluggish in their movements, and are found upon the twigs and leaves of plants, to which they bear a striking resemblance. In fact, the species of this family are all imitative in a greater or less degree, and furnish the strongest examples of that mimicry which is so frequent among insects, and which brings them into harmony with their surroundings and enhances their protection. The body in most of the Phasmidæ is remarkably long and slender, and the

wings are either aborted, very small, or strikingly leaf-like. The head is long and horizontal, while in most of the species the antennæ are rather short. The legs are of the ordinary type, being made neither for jumping nor seizing, and, as a rule, quite long and stick-like. When the insect is at rest the front pair are stretched out in front so as to increase the resemblance to a twig. The characters by which the insects of this family are

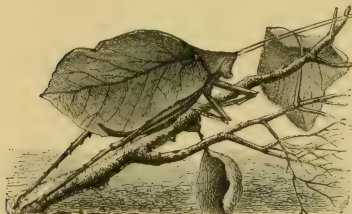


FIG. 232. — Leaf insect.

classified are similar to those used in other families in the Orthoptera. The antennæ, however, acquire more or less importance in different genera. Although there are a few representatives of this family in the United States, they find their most congenial home in the tropics, where some of the species attain to over a foot in length, exclusive of the legs.

The walking-sticks are strictly herbivorous, and in color closely imitate the plants upon which they feed. Their eggs are oval or elliptical, and have a lid on the front end which is pushed open by the young larva when it is ready to escape. They are dropped singly on the ground. The larvæ differ but little from the imago except in size and in their greenish color. Their mode of life varies somewhat from that of their parents. During the first few weeks they generally live upon grass and low bushes, where they readily drop to the ground when disturbed, thereby escaping notice. The transformations of but few of the Phasmidæ have been studied. We cannot, therefore, be positive as to the number of moults suffered by the representatives of the various genera. The history of *Diapheromera femorata* has been carefully studied by Riley. The eggs are oval, slightly compressed at the sides, polished black in color, with a ventral whitish stripe, and look something like small leguminous seeds. They are tough and are simply dropped upon the ground from whatever height the female happens to be, so that during the latter part of autumn where the insects are common they produce upon the dry leaves a constant pattering not unlike that of rain. The number of eggs laid by a single female is near a hundred. They remain upon the

ground all through the winter and hatch for the most part during the month of May. Some of them, however, continue hatching much later, so that all through the summer and even into the fall, young individuals may be found. The embryo, just about to hatch, lies within the egg with the head pressed against the oval lid and the body curled round so that the end of the abdomen, which is thickened and contracted, reaches near the mouth. The long antennæ project in front of the head and follow the curve of the body, while the long legs are folded up in the central space. When hatched, the young of this species measures 4.5 mm., and with their feelers and legs outstretched, nearly double that length. The insect changes very little in appearance from birth to maturity except so far as color is concerned. Growth is rapid, averaging, under favorable circumstances, about six weeks from birth to maturity. With age the green color gives way to various shades of gray and brown, though exceptional individuals remain green. In other words, these insects put on their autumn tints just as does most of the deciduous vegetation. In this way we find great correspondence with its surroundings. While the vegetation is green the *Diapheromera* is green; when the foliage turns in autumn it changes color accordingly. The species has become very numerous in parts of the Middle States, where it does great injury to various trees, especially to the oaks. The eggs of this species often lie on the ground through two winters before hatching.

The species of the genus *Phyllium*, found only in the East Indies, bears a most remarkable resemblance to various leaves. The wings are often very large and broad, and, as if to aid in carrying out the analogy, the legs have broad, leaf-like expansions. One species has its front wings so veined and colored as to resemble a dried and withered leaf, while *Phyllium siccifolium*, which we figure, is green. *Prisopus flabellicornis*, a Brazilian species, according to A. Murray, spends the whole of the day under water, adhering to stones in cool mountain streams till



FIG. 253. — *Diapheromera femorata*, walking stick; a b, eggs.

toward dusk, when it flies about. This is the only true aquatic orthopterous insect known.

In contemplating these singular creatures and their wonderful resemblances to the vegetation upon which they occur, one cannot help noticing still further resemblances. They are born with the bursting of the buds in the spring; they drop their eggs as the trees drop their seeds, and they commence to fall and perish with the leaves, the later ones persisting, like the last leaves, till frost cuts them off. We have not more than a half dozen representatives of the Phasmidæ within the limits of the United States.

We now come to that extensive division of the Orthoptera known as the Saltatorial Orthoptera. This division contains by far the greatest number of species, each of which possesses rather exceptional powers of jumping or leaping, and hence has the

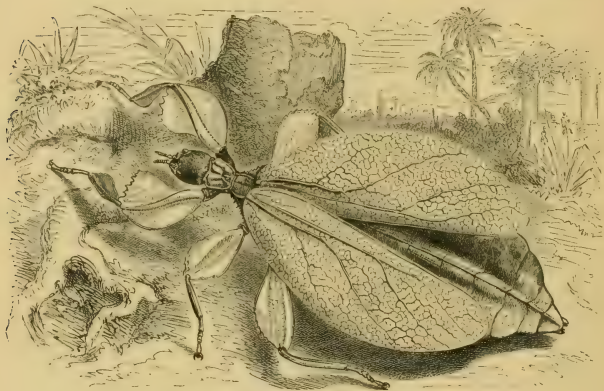


FIG. 254.—*Phyllium siccifolium*, walking-leaf.

hind femora greatly developed for this purpose. While this character is common to all the Saltatoria the division is readily separable into three very distinct families. These families are the Gryllidæ, or crickets, the Locustidæ, or grasshoppers and katydids, and the Acrididæ, or locusts. While the families comprising the crickets and katydids differ from each other in many respects, they are nevertheless very closely connected in some of their wingless genera. They possess common characters, and have similar habits; many of the species in both families being wingless, and having somewhat similar shapes. The antennæ are long and threadlike in both. The Acrididæ, on the contrary, are widely separated from the rest of the Orthoptera in most of their characters, and are the most highly organized representatives of the order.

We will mention these families one by one, and characterize each, in its turn, by describing a few of the commoner species as well as those that are odd, and deviate somewhat from the typical form.

The GRYLLOIDE, or Crickets, are characterized by having a somewhat cylindrical body, and a large, vertical head, with elliptical eyes; the antennæ are long and thread-like, and arise between and in front of the eyes; the wings, when present, are of moderate size and net-veined, and lie flat on the back; the anterior pair are ovate, and have the costal edge bent abruptly down at the sides of the body, while the hind pair are triangular, net-veined, and folded like a fan. The genital armature is largely developed, forming long and slender exarticulate stylets, which are often nearly as long as the body. The ovipositor is of variable length, cylindrical, more or less curved upwards, with the end slightly enlarged and wedge-shaped. The prothorax is generally small, and shield-like; the legs are rather short, but well suited to the habits of these insects. The legs are also often armed with long, sharp spines, especially among the ground-dwelling species, and in their various modifications form an excellent character for classification. The characters most used in classification are primarily the form, but also the antennæ, ovipositor, posterior tibiæ, and the labial palpi.

The colors of the field crickets, as a rule, are various shades of dull black, or brownish-gray, agreeing well with their nocturnal and ground-dwelling habits. They are hermit-like, and very retiring, especially during the daytime, almost always living singly, in little burrows, which they dig for themselves, and from which they seldom stray far. They are timid, and generally peaceful among themselves, as well as towards other insects with which they come in contact.

In treating of the foregoing families of the Orthoptera we mentioned a great variety of features belonging to each and all, some of which were interesting as well as unique; but in none did we find the power of song. The saltatorial Orthoptera, or at least all such of them as possess wings, are capable of producing sounds by stridulation, which, among the Gryllidæ and Locustidæ are not unpleasant to the ear, and may be likened to the songs of birds. It is from this feature that they have become more popularly known than are most of the other Orthoptera.

While the preceding families are chiefly confined to the tropics, and to the warmer parts of the temperate countries, the Gryllidæ are more equally distributed over the earth's surface where the climate is sufficiently warm to permit of their maturing. They are herbivorous, but not strictly so, since they are known to devour dead animal matter, and to prey upon other soft insects.

The lowest type of this family, as it is at present limited, is composed of what may be called the Fossorial Orthoptera. These are among the "rarities" of insect life, on account of their secluded habits. They are odd looking creatures, and bear a striking resemblance to the mole, with its greatly developed front legs modified for burrowing. These Mole-crickets, as they are called, are of rather large size, and have their members admirably adapted to burrowing. They live underground, and very seldom leave their burrows to come to the surface, and then always after dark. Their bodies are almost cylindrical, quite long, and densely covered with very short, fine hairs; their feet are short and thick; their front, or burrowing legs, are short, and greatly enlarged, and, as it were, fingered, so as to greatly resemble in appearance those of the common mole. They do not jump, like the rest of the Gryllidæ, nor is there any necessity for this accomplishment in the subterranean life they lead. They are the true moles of the



FIG. 255. — *Gryllotalpa australis*, mole-cricket.

insect world, and make tortuous galleries, destroying everything that comes in their way, cutting through roots and eating the fine underground twigs, as well as the worms and grubs, which they meet with during their burrowings. Some authors have claimed that these crickets are truly carnivorous, but this is a mistake. They do eat such worms and insects as come in their way, but their nourishment consists principally of vegetable food. Their excavations consist of vertical shafts, of various depths, and of horizontal galleries, which lead from them in different directions. These are to be found in the soft, moist earth on the margins of streams and about ponds, where they can be readily detected by the small upraised ridges, like those made by the mole.

The female *Gryllotalpa* lays her eggs, to the number of three hundred to four hundred, in the remotest part of the gallery. They are laid in the spring of the year, and are contained in tough sacs.

The males sing during the warm, still nights of spring and early summer. The song is a low, continued, rather pleasant trill, quite similar to that of the common toad, but more shrill. It is produced by rubbing together the anterior wings, which are furnished with heavy veins, roughened on their contiguous surfaces, and so arranged as to magnify the sounds.

The species are all of a dirty, brownish-gray color, and resemble one another very closely. They are quite generally distributed over the inhabited world, though they become more numerous towards and within the tropics. *Gryllotalpa borealis* is found throughout the northern part of the United States and portions of British America, while further south it is replaced by *Gryllotalpa longipennis*. In Europe *Gryllotalpa vulgaris* is the most widely disseminated species. It is figured in the accompanying plate, where a female is illustrated in the act of coming out of the shaft, in the bottom of which are eggs. A male is shown in the act of flying, and the young are seen crawling about on the surface of the soil. One species of mole-cricket is very numerous in the West Indies, where it does great injury to sugar-cane. There are about two dozen species described, from various parts of the world.

A second genus of this family is that known as *Tridactylus*, the members of which are all small and insignificant in appearance, the largest being but about one-third of an inch in length. They bear a slight resemblance to the *Gryllotalpæ*, and are found in similar localities, where they sometimes burrow in the soft, moist earth, or sit on the low herbage. They are very active, and possess the power of jumping in the highest degree. They derive their name from the peculiar structure of the anterior tibiæ and tarsi, which in the male have the appearance of being three-parted, or fingered. The different species are variously colored with black and white, the black portions being very highly polished. *Tridactylus epicalis* is found in the south, while *Tridactylus variegatus* is the most common species in Europe. There are but about a dozen described species of these small crickets. They are supposed to be entirely herbivorous, and they lay their eggs in the ground, near streams and ponds. These crickets are found in all stages the year round, but their principal period of multiplication is in the spring.

We now come to that large tribe of this family which contains the common house cricket, and the field species of this country and of Europe. They are among the best known of all insects, and from their habit of hiding about the hearthstone have been made the theme of many a pleasant ditty. Each one digs for itself a hole, which it seldom leaves except at night. During the day they often sit with their heads out of



Gryllotalpa vulgaris, mole crickets.

the holes and merrily chirp their little love-songs, but at the first faint disturbance the songs cease and the crickets disappear.

The House Cricket, *Gryllus domesticus*, which is of a yellowish-gray color more or less marked with brown tints, is smaller than the common field species, and hides itself in holes and cracks in old walls and chimneys. It is sensitive to cold, and delights in warm places. In towns it prefers bakeries and the neighborhood of ovens, and in the country the most humble kitchen is favored with its merry chirp. It is common throughout Europe, and has become quite common also in some of the eastern cities of the United States, where it has been introduced from the Orient. Blending with the ever-welcome croaking of the frog — that surest harbinger of spring — the first insect note we hear is the shrill chirrup of an occasional field-cricket; for a few of these little black burrowers in the ground manage to live through the winter in the winged state. Our two largest species of field-crickets are *Gryllus luctuosus* and *Gryllus abbreviatus*. The former has very long clytra or fore-wings that project beyond the end of the abdomen, while in the latter they are somewhat abbreviated. In New England, as well as the middle northern States, *Gryllus neglectus* is the most common species, from which *Gryllus nigra* differs in having a much shorter ovipositor. In addition to these species there is a much smaller one, *Nemobius vittatus*, that is exceedingly common in our fields and pastures during the latter part of summer and fall. All of these crickets are herbivorous, and are especially fond of congregating under piles of straw and other decaying vegetation where heat is generated. They also frequent granaries and barns, where they find plenty to sustain life, and get protection from their dread enemies, the birds.

The eggs of these crickets are laid loose in the soil to the number of from two hundred to four hundred for each female, and chiefly during the autumn. There are a great many allied genera of Gryllidae found in various parts of the world, all of them having similar habits to those which we have described.

In this family we find the smallest and most delicate of the Orthoptera. There is a genus of crickets (*Myrmecophila*) the members of which live in the nests of various species of ants. These diminutive species are very active, and at first glance resemble very closely the quite young larvæ of certain roaches that are also frequently met with in similar localities. This resemblance is so close that the commonest European species, *Myrmecophila acervorum*, was first described as *Blatta acervorum*. This species is most frequently met with in central and southern Europe, where it lives with such species of ants as make their nests under stones. It is of a somewhat globular form, without wings, and has the posterior femora enormously developed. It is of a pale, dingy-brown color, opaque, and measures 3 to 3.5 mm. in length. A second and smaller species, *Myrmecophila ochracea*, is found in south Germany and Switzerland. In the United States, *Myrmecophila pergandii* is frequently met with in ants' nests in the vicinity of Washington, while a single specimen has been taken in Washington Territory.

Before leaving the crickets which dwell in the ground we must mention several representatives of a group which is essentially tropical, and in which the front of the head is produced into a leaf-like projection. One of these, *Platyplemmus lusitanicus*, is found in Spain and Portugal, where it lives under stones and fallen leaves. *Strophoblennius humbertiellus* is found in the island of Ceylon. It has the front of the head produced into a sort of crown.

In addition to those crickets which dwell on the ground there are many which are arboreal. They are known as tree-crickets, and prevail most in the tropics, though

several occur in Europe and in the United States. The tree-crickets are brightly colored, and resemble at first glance some of the smaller Locustidæ which live among trees. They all lay their eggs above ground, either upon the plants on which they most frequently occur, or upon some other plant in close proximity. The mode of egg-laying differs greatly in the various genera, and sometimes among the species of a single genus.

The Snowy Tree-Cricket (*Ecanthus niveus*) is of a delicate greenish, semi-transparent white, though some specimens have a blackish shade. This cricket, although known to devour plant-lice, and likewise the eggs of some moths, is injurious to vegetation, gnawing the stems of grapes so as to cause them to fall, and puncturing, for purposes of oviposition, the twigs of various plants. Among plants chosen are the vine, raspberry, blackberry, peach, white willow, and soft maple. In depositing she makes a straight, longitudinal, contiguous row of punctures, each puncture about the size of that which would be made by an ordinary pin. From each of these holes a yellowish elongate egg runs slantingly across the pith, as shown in the accompanying illustration. The twigs or canes thus punctured almost invariably die above the punctured part. The chirp of this species is intermittent, resembling a shrill "te-reat, te-reat, te-reat," with a slight pause between each.



FIG. 256. — *Ecanthus niveus*, tree-cricket.

The Broad-winged Tree-Cricket (*Ecanthus latipennis*) is much like the preceding, but larger, and the female lays her eggs chiefly in grape-caness, drilling a single hole at intervals of about one-third of an inch. The jaws are first used to slightly tear the outer bark. With the antennæ stretched straight forward, and the abdomen bent up so as to bring the ovipositor at right angles with the cane, she then commences drilling, working the abdomen convulsively up and down about twice each second. The eggs are laid lengthwise in the pith, but always in two sets, one each side of the hole. The number varies according to the size of the cane, and the distance between the holes is also variable. The hole is usually filled up with a white mucous secretion, though there is very little of it about the eggs. This secretion also doubtless serves to facilitate the drilling. The same female will lay over two hundred eggs, and will sometimes puncture the same cane at intervals of one-third inch for one and a half feet or more.

The shrill cry of *latipennis* is continuous and recalls the trilling of a high-pitched dog-whistle in the distance. The key varies, however, and is sometimes much less high and more musical than at others. The commingled shrills of this species recall also the distant croaking of frogs in spring. The broad wings are thoroughly elevated during the act, or even bent forward, and the vibration is so rapid that there appears to be no motion.

Orocharis saltator, which is found throughout the warmer parts of the middle and eastern United States, is of a pale yellowish-brown color. The female differs from the male in possessing a long ovipositor and in having the wings more rounded and less ribbed and veined. She lays her eggs in the corky, rough bark of the trunk and older

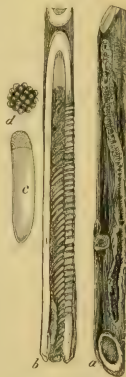


FIG. 257. — *a b*, Stem of blackberry with eggs of *Ecanthus niveus*; *c*, egg enlarged; *d*, ornamentation of egg.

branches of the American elm, the eggs being thrust in singly or in small batches, either longitudinally with or slightly obliquely from the axis of the trunk or branch. The female is very intent in the act, working her abdomen deliberately from side to side during the perforation. The ovipositor is held more obliquely in this genus than in *Ecanthus*.

The stridulation of this cricket is a rather soft and musical piping of not quite half a second's duration, with from four to six trills, but so rapid that they are lost in the distance. The key is very high, but varies in different individuals and according to moisture and temperature. It most resembles the vibrating touch of the finger on the rim of an ordinary tumbler when three-fourths filled with water, repeated at intervals of from two to four per second, and may be very well likened to the piping of a young chick and of some tree frogs. As the species is very common in the Southwest, its chirp is everywhere heard, and is so distinctive that when once studied it is never lost amid the louder racket of the katydids and other night choristers. It is also frequently heard during the daytime when the weather is damp and cloudy. *Hapithus agitator* is a more robust and darker brown species than the preceding, and approaches more closely the ground-dwelling species in form and general appearance than do any of the other true tree-inhabiting crickets of this country. It is very active at night, when it can be seen running and jumping about on the trunks of various trees in the bark of which the female lays her eggs. During the daytime these crickets hide among the dense foliage of vines or the rank vegetation on the ground at the base of the trees. Another very interesting genus of Gryllidae is that known as *Phylloscirtus*, all the members of which are small and delicate and brightly colored. *Phylloscirtus pulchellus* is common about Washington and southward, and is found most frequently in low, wet woods. It also deposits its eggs in the bark of various trees.

The LOCUSTIDÆ is a very extensive family, and contains a few of the most interesting species of saltatorial Orthoptera. The family includes those species usually found on the grass, bushes, and trees, and which have very long thread-like antennæ, generally longer than the body of the insect; the tarsi or feet are as a rule four-jointed; the female is furnished with an exerted ovipositor which is usually more or less curved and sword-shaped; and the elytra of the male have at their base a development and arrangement of the veins wherewith stridulation is effected. To this family belong the true grasshoppers, the katydids, and similar insects.

There are two types of Locustidæ, viz., those which possess wings and those in which these appendages are wanting. In the winged forms the head is perpendicular, large, with the vertex more or less produced into a cone-like projection which in a few of the genera is very long and gives to their members a striking appearance. The eyes are globular and prominent; the antennæ, which are situated as in the preceding family are very long and thread-like—in some instances measuring fully twice the length of the insect. The elytra are long and slender, much veined, and in the male are provided with a transparent drum-like apparatus which is used in the production



FIG. 258. — *Orocharis saltator*; a, female; b, male.

of the characteristic song of these insects. The hind-wings are also long and much veined, and are folded up lengthwise and tucked away under the elytra, beyond the tips of which they project a trifle in some of the species. The base of the front tibiæ or shanks is somewhat dilated, with an oval cavity each side closed by a membranous covering. The genitalia are greatly developed; in the female into a long, sword-shaped ovipositor, and in the male into strong, pincer-like claspers. The body is short, compressed, and somewhat arched. The prothorax is free and covered by a saddle-shaped shield, which is a prominent feature of the family. The members of this division are chiefly of green and brown colors, which agree well with their environment.

The wingless Locustidæ have the head as in the winged genera, save the cone-like projection of the vertex. It is also more deeply set in the prothorax, which latter is not so distinctly free from the abdomen as in the winged forms. The legs are shorter and stouter, and are furnished with longer spines, thereby showing a relationship to the members of the preceding family, which they closely resemble in many of their characters. These wingless genera live chiefly on the ground and in crevices among rocks. Their habits are somewhat similar to those of many of the Gryllidæ; and their colors are also modest and inconspicuous, various shades of gray or brown predominating. As we shall see, the eggs of many of the American Locustidæ are laid above ground, while most of the European species oviposit in the ground.

As their name implies, the stone crickets, which are wingless and soft-bodied, live under stones and in crevices among rocks. There are a number of species found within the limits of the United States, and they may be recognized by their arched bodies and mottled colors. *Ceuthophilus maculatus* is found in the New England States, and is distinguished from all other species by the males having the posterior tibiæ waved at their base. *C. lapidicolus* inhabits the country from Pennsylvania southward, where it takes the place of the preceding species. *C.*



FIG. 259. — *Ceuthophilus maculatus*, wingless cricket.

uhleri, a Maryland species, is of a reddish-brown ground-color with lighter mottlings. *C. divergens* lives under logs and stones in Iowa and Nebraska, while *C. stygius* is from Kentucky, where it inhabits caves. There are still a number of other species of these crickets found in various localities throughout North America. There are also a few met with in Europe and other parts of the world, where they possess similar habits.

The true cave crickets, of which there are three known species, belong to the genus *Hadenæcus*. These locustarians have very long limbs and antennæ, and are colorless and blind. *H. cavernarum* inhabits the caves of North America, while *H. palpatus* lives in those of Europe. The third species, *H. edwardsii*, is from New



FIG. 260. — *Hadenæcus cavernarum*, cave cricket.

Zealand, where it was captured by Mr. Henry Edwards in a cave close to the seashore and near a very large coal deposit. These insects are by no means uncommon

in caves where found, and, as a rule, prefer the vicinity of streams of water which percolate through the rocks. They are very difficult to capture, since they disappear in the crevices of the rocks on the approach of lights.

Throughout the Rocky Mountain region and the great interior basin of the West are found several species of large, fierce-looking insects that live under stones and in the loose soil, from which they are frequently turned up by the plough in spring. They are popularly known as sand-crickets, and are supposed to be more or less carnivorous, varying their vegetable diet with insects which they capture during their nocturnal ramblings. They belong to the genus *Stenophelmatus*, the members of which are all large and clumsy, and, as a rule, of a dirty yellowish-brown color, more or less marked with black. *Stenophelmatus fuscatus* is most frequently met with in Idaho and Utah, where it lives under stones and in the sand during the daytime, and creeps about at night. *S. ocellatus* is found in Colorado. Like the mole-crickets, which they approach in habit, they are unable to jump, and are therefore exceptional among the Saltatoria.

In the same locality with the preceding, and throughout all of that portion of North America, south of the Saskatchewan and west of the Mississippi rivers, are found various species of wingless Locustidae which are known as western crickets. *Anabrus simplex*, a large, dark-colored species which we figure, is the nomadic cricket of the far West, which has frequently appeared in vast armies and done much injury to the grain crops and garden truck of the earlier settlers. It is confined in its distribution chiefly to the elevated sage wastes and mountain slopes, from which localities it makes occasional visits to the fertile valleys below, marching in solid phalanx like an advancing army, and devouring everything green in its path.



FIG. 261. — *Anabrus simplex*, western cricket.

Although herbivorous by nature, when pressed by hunger these stone-crickets will not refuse animal food. This carnivorous habit is known to the farmers, and is taken advantage of in some portions of the cricket area. Ditches are dug across the line of the marching army, and when the crickets arrive at and attempt to cross one of them, they tumble in and cannot escape. Once in the ditch, they are deprived of food, and, becoming desperate, begin to attack and devour one another. It is claimed that in this manner great numbers perish.

The female, by means of a strong ovipositor, lays her eggs in the ground. The abdominal appendages of the males are crooked and toothed, and form a strong clasping device resembling a pair of pincers. The males are furnished with a musical apparatus which is situated on the dorsum immediately behind the large saddle-shaped shield which covers the prothorax. The song is a sharp grating, something similar to that produced by drawing the point of a sharpened quill over the rough surface of a coarse file or sandstone. This species is confined to the western slope of the Rocky Mountains, while *Anabrus purpurascens*, which is of about the same size, is met with on their eastern slope, and extends as far east as the Mississippi river, and far to the north and to the south. It differs from the foregoing species in its much more slender form and lighter color. There are several other species distributed over the central portion of the continent, as a rule confined to the more elevated plateaux.

Camptonotus scudderi is found in the Atlantic States, from Delaware southward where it dwells among trees, especially the various species of oak. It is a very interesting species, and possesses characters belonging both to the stone crickets and the true green grasshoppers. Its form is similar to that of the former, while the head is large, oval, and much broader than the prothorax and not deeply sunken into it. The eyes are ovate and situated on the sides a little back of the basal joint of the antennae, which they exceed a trifle in length. The antennae are remarkably long, being at least five times the length of the body exclusive of the ovipositor, which is ensiform, curved upwards, compressed and acute, reminding one of the ovipositors of some of the grasshoppers. The legs are very short and moderately stout, and furnished with spines and cushion-like tarsi well adapted to the uses to which they are put. The species is of an ochreous-yellow color above, pale beneath, with black eyes and a dark spot on the dorsum posteriorly. It is active and shy, and during the day conceals itself by drawing together the edges of leaves or by using the deserted nests of some caterpillar. While thus hidden, its long antennae are wrapped several times around its body. There is an allied species which is known to inhabit the island of St. Thomas. Both species are apterous and without musical apparatus.

The true grasshoppers and katydids, with which every one is familiar, are all essentially herbivorous, and live among the dense foliage of trees as well as of all sorts of shrubs and other low vegetation, where they remain quiet during the warmer part of the day. These are the merry choristers that make our woods and valleys ring with their pleasant songs during the evenings of late summer and early fall. They are chiefly nocturnal in their habits, but not entirely so, for each afternoon during their courting-time, and long before the sun has disappeared in the west, a few of them may be seen flying about from place to place, while others are occasionally heard in their retreats as though tuning their instruments preparatory to the grand evening concert.

These interesting and well-known locustarians are to be met with in all countries that lie within the temperate and torrid zones; and while the species are of moderate size and plainly colored in temperate climes, they are of great variety both as to size and form, and color, in the warmer countries.

Xiphidium fasciatum, a small meadow grasshopper, common throughout the New England States, has the ovipositor straight and sword-shaped. *X. brevipennis*, as the name indicates, has the wings abbreviated; it also differs from the preceding species, which it otherwise resembles, in having the ovipositor reddish-brown throughout, while in *X. fasciatum* it is green at its base. *X. ensifer*, which is met with in the South and West, has the ovipositor very long and

FIG. 262. — Wing of *Orchelimum vulgare*; a, stridulating organ.

straight, and of a brownish color which deepens toward the apex. All our species live among the low vegetation of meadows and open grassy fields, where they deposit their long, cylindrical whitish eggs, which are either thrust into soft pithy stems or inserted between the leaf-sheaths and stems of various grasses. They are generally laid in a series of from six to a dozen or more one against the other. In Europe there are a few species of this genus, while others are known to inhabit portions of Asia and Africa.

The female of the smooth, glassy-green meadow grasshopper, *Orchelimum glaberrimum*, which is common throughout the United States east of the Rocky Mountains,

oviposits in the stems of various pithy plants, and especially in the tassel stem of Indian corn. *O. vulgare* possesses similar habits and is found throughout the eastern and middle States. *O. concinnum* is from Massachusetts, and has the wings a trifle longer than the elytra, while *O. longipennis*, a Texan species, has the elytra and wings very long. It also has two narrow brown bands along the top of the pronotum.

There are several genera and many species of these green grasshoppers in which the vertex of the head is produced into a cone-like projection. The species are all moderately large, and have the elytra long and leaf-like. Their legs are also long and slender, and the antennæ filiform; the ovipositor is long, flat, and sword-like. These insects live in the grass and in trees, having, in fact, much the same habits as the katydids, to which they bear a striking resemblance. *Conocephalus ensiger* is the commonest species throughout the eastern portion of North America. It is generally of a pea-green color, though an occasional individual is found which is of a brownish straw color.



FIG. 263. — *Conocephalus ensiger*.

The female lays her eggs between the root-leaves and stems of various plants. *Conocephalus robustus* is a much stouter species than the preceding, and has the elytra, which are either green or light brown, irregularly dotted with minute black spots. It has been taken on the sea beach at Cape Cod. *C. obtusus* is a Georgian species, and *C. macinatus*, which has robust legs, is cited as coming from Alabama. *C. mandibularis* is found throughout southern Europe, where it frequents wet meadows.

Copiophora mucronata, in which the cone-like projection is very long, has been taken in the greenhouse connected with the department of Agriculture in Washington, D. C., where it must have been reared from eggs that were brought with plants from some tropical country. It is a short, thick-set insect with much shorter and stronger limbs than possessed by any of the species belonging to the genus *Conocephalus*. The wings are also proportionately broader and shorter than in the members of that genus. There are eight other described species of *Copiophora*, all of which inhabit various parts of equatorial America and adjacent islands.



FIG. 264. — *Copiophyllus concavus*, katydid.

The true katydids, of which there are at least a dozen species found in the United States, are at once recognized by their large size, broad and leaf-like wings, and bright green colors. They are strictly arboreal in their habits, and spend the greater portion of their lives among the rich, green foliage which they so closely imitate in color. *Cyrtophyllus concavus*, the true Katydid from which the popular name is derived, is met with throughout the central and eastern States. This and an allied species,

which is found in the South, are our only representatives in which the length of the wings is exceeded by the length of the wing-covers. These are very broad and

convex, entirely closing the body, and, with their strong midrib, closely resemble a leaf.

In a previous article we have described this species in the following language: "The ovipositor of the female is almost as long as the abdomen, cimeter-shaped, sharp-pointed, and with slight serrations on the lower edge toward the tip. Both sexes have two thorn-like projections, on the breast, between the front legs, and the membranaceous spots on the dilated base of the front tibiae are convex rather than concave, and look like little pockets from above. The eggs are thrust by means of the sharp ovipositor, into crevices and soft substances, and probably, in a state of nature, into the crevices of loose bark, or into the soft stems of woody plants. In the breeding cage I have had pieces of cork filled with them, and they have often been crowded between the crevices and sutures of my cages, especially where the cap rests on the cage proper. These eggs are 0.25-0.30 inch long, very flat, over thrice as long as wide, pointed at each end, with the edges bevelled off or emarginate. They are of a dark slate color, and the lower or first inserted end is protected by dark, adhesive substance, which hardens and sometimes extends the whole length of one of the borders. Several eggs are usually pressed close to each other." The southern species, *Cyrtophyllus perspicillatus* differs from its northern ally in its shorter, but equally broad elytra, in the slightly broader musical apparatus of the male, and in the stouter legs.

Amblycorypha rotundifolia is a small species with oblong elytra, which is very common throughout the Northern States and Canada. The ovipositor is quite broad,



FIG. 265. — *Amblycorypha rotundifolia*, round-winged katydid.

much curved and roughly serrated both above and below. *A. oblongifolia* is a large species found in the same locality with the above. It has the ovipositor less serrated and less curved. *Amblycorypha caudata*, which is a still larger insect, and in which the ovipositor is very long, is from the Southern States. *A. uhlerii* is our smallest species, and is

common around Washington. Their eggs are slate-colored, and shaped like those presently to be described. We have had them loosely laid in our vivaria, but the structure of the ovipositor indicates that they are, in nature, secreted like those of *Cyrtophyllus*. These katydids are closely allied to the members of the following genus, which they resemble in many respects.

The Angular-winged Katydid, *Microcentrum retineris*, is our commonest North American species, and as can be seen by reference to the illustration, has large and ample wings, comparatively short but stout hind femora, and a short and much curved ovipositor. As its habits have been more carefully studied than those of any of our other katydids, we quote from the sixth report on the Insects of Missouri, where the life history of the species has been fully set forth.

"The females commence to oviposit early in September, and continue to lay at intervals until the first severe frost. The eggs," which are oblong and flat, "are occasionally deposited during the day, but the operation usually takes place at night. Selecting a twig of about the size of a common goose-quill, this provident mother prepares it for the reception of her eggs by biting and roughening the bark with her jaws for a distance of two or three inches. This bite is not gradual, like that made when feeding, but is sudden and vigorous, the insect chewing and pressing the twig

each side so as to form an edge. This operation is accompanied by a sudden, nervous shake of the body from side to side, and lasts sometimes but two or three minutes, sometimes more than ten. When the operation is accomplished to her satisfaction, she clutches with her front feet the stem to be used, and anchors the middle and hindmost feet for the most part upon contiguous leaves or branches, and often quite wide apart. Then, if she has her head in an upward direction (for it seems to be immaterial to her whether the eggs are placed from below up or *vice versa*), she begins at the lower end of the lower portion of the twig, and, after fretting it anew with her jaws and measuring and feeling it over again and again with her palpi, as if to assure herself that all is as it should be, she slowly — with much apparent effort, and not without letting it partly fall several times — curls the abdomen under until the lower edge of the ovipositor is brought between the jaws and the palpi, by which it is grasped and guided to the right position. It is then worked slightly up and down for from four to six minutes — all the time guided by the jaws — while a shiny viscid fluid is given out apparently from the ovipositor. Finally, after a few seconds' rest or suspension of this work, the egg gradually rises, and, as it passes between the ovipositor, turns so that one end appears almost simultaneously, from between the convex edge, with the other from the lower tip, of the blade. The egg adheres to the roughened bark in an oblique position. It is at first almost black and highly varnished, but it acquires its normal gray color within eight or ten hours. After the egg is placed the abdomen is straightened out, and the insect rests for a few moments, soon, however, to resume her efforts and repeat the like performance, in every particular, except that the second egg is placed on the opposite side of the twig and a little above the first one. The third egg is pushed in between the top of the first one and the twig, the fourth between the top of the second, and so on, one each side, alternately. Thus these eggs are not laid, as we might naturally imply, one over the other, but, rather, one under the other; i. e., each succeeding pair having their ends thrust in between the tops of the preceding pair, the teeth at the end of the ovipositor helping to crowd the end into place.



FIG. 295. — *Microcentrum retineris* ovipositing.

"The number of eggs laid at one time varies from two to thirty, the first batches containing more than those deposited later in the season. Each female produces from one hundred and fifty to two hundred, or perhaps more, and I have known them to lay on the edge of a leaf, or of a piano-cover, or a long piece of cord.

"These eggs, as already remarked, are rather flat when laid, but become more swollen, so that they have a narrower look as they approach the period in spring.

During the early part of May the embryo larva — which lies straight in its egg, completely filling it, with the legs bent up as in a pupa, and the long antennae curling around them — attains its full development, and after hours of tedious contracting

and expanding movements, manages to burst the egg open at its top or exposed end, along the narrow edge, and generally about half way down. Through this opening



FIG. 267. — Eggs of *Microcentrum retroversis*.

young Katy slowly emerges, undergoing a moult during the process, and leaving its first skin, in a crumpled white mass, attached to the empty bivalvular egg-shell. Including the hind-legs and antennæ, it measures, at this time, rather more than an inch in length, the body alone being one-eighth of an inch long; and in contemplating it, one cannot but wonder how the long, stiff legs and great length of antennæ, together with the plump body, could so recently have been compressed into the comparatively small shell to which we see it clinging.

"In from ten to twenty minutes after, these little beings essay their first leaps, and soon begin to eat with avidity. They feed with almost equal relish upon a great variety of foliage, but I have found that when reared upon very succulent leaves, such as lettuce, cabbage, purslain and the like, they are less hardy, and do not attain so great an age as when nourished upon more ligneous food, as the leaves of oak, apple or cherry.

"The larval life of these insects lasts from seven to eight weeks. Shortly before the change to pupæ, which takes place toward the end of June, the rudiments of the wings and of the sexual organs may be distinguished. In the pupa state they are quite pretty, and their faces have a comically wise look, and every motion is invested with a sort of dignity that cannot fail to amuse the observer.

"Including the moult in leaving the egg, they cast their skins five times, becoming pupæ at the fourth, and acquiring wings at the fifth. In each case the palpi are adroitly used to help the long antennæ out of the old skin, and a description of the last, which is more easily watched, will convey a correct idea of all. In changing from the pupa to the perfect form, the insect stations itself firmly upon a large stem, or a couple of twigs which branch in such a manner as to afford a convenient support, and, after a short period of inactivity, a rupture appears in the covering of the head, and gradually extends backward to the posterior edge of the thorax. The armor of the head is next detached from the neck, and by a few upward and downward motions is made to slide off in front, the long, thread-like antennæ being drawn out of their shields with great care, in constantly lengthening loops, the palpi affording much assistance in pushing the old skin downward. After the head and antennæ are entirely freed the insect remains for a short time motionless, as if to recover from its exertions. Very soon, however, it renews its efforts in a series of rapid jerks and contractions, by which the body is impelled forward while the outgrown skin is held firmly in place by the claws of the middle and posterior legs, which remain fixed in the wood. The most difficult part of the whole process seems to be the extrication of the front legs. This once accomplished, the katydid has something to grasp with, and experiences no further trouble in withdrawing the body and the remaining legs from the old integument, often leaving the latter, as an almost transparent shell, in perfect shape upon the twig. It is not allowed to remain long, however, as an object of curiosity, for almost the first efforts of the transformed insect are directed to the task of eating up this, its outgrown and outworn garment.

"When first out of its pupal covering the wings of the mature insect hang down

on each side as flexible and shapeless as strips of dampened lace, but soon they begin to dry and harden, and are, by degrees, drawn up into place. The anterior pair, which were at first transparent, become gradually green and opaque, and display the characteristic leaf-like veinings; while the broad under-wings, formed of transparent membrane, intersected by an exquisite network of green veins, are folded fanlike beneath them, with only the tips, for about a third of an inch, visible, this portion being green and thickened like the wing-covers. The whole operation of moulting is performed within an hour.

"The first notes from this katydid are heard about the middle of July, and the species is in full song by the first of August. The wing-covers are partially opened by a sudden jerk, and the notes produced by the gradual closing of the same. The song consists of a series of from twenty-five to thirty raspings, as of a stiff quill drawn across a coarse file. There are about five of these raspings or trills per second, all alike, and with equal intervals, except the last two or three, which, with the closing of the wing-covers, run into each other. The whole strongly recalls the slow turning of a child's wooden rattle, ending by a sudden jerk of the same; and this prolonged rattling, which is peculiar to the male, is invariable and instantly answered by a single sharp 'chirp' or 'tschick' from one or more females, who produce the sound by a sudden jerk upward of the wings."

Microcentrum affiliatum, a closely allied species, has the same range with the preceding. It is a larger insect, and is nowhere so common as *retinervis*. In Central and South America occur several very large species, which belong to closely allied genera.

Our remaining species of katydids belong to the genus *Phaneroptera*, of which *Phaneroptera curvicauda* is the best known species. It is a much more slender insect than the others noticed, and the ovipositor is broad and greatly curved. The eggs are laid singly in the edges of leaves, between the upper and lower cuticles, and are so thin that they are not noticeable except when the leaf is held between one's self and the light. They swell very considerably, however, in the spring, before hatching.

The genus *Locusta*, which contains the typical species of the family, is composed of large, strong-bodied insects, which are furnished with long, narrow elytra, and broad wings. The females are provided with long ovipositors with which they place their eggs in the ground. *Locusta fuliginosa* is confined to the arid plateaus of the great interior basin, where it lives on the low and sombre-colored vegetation. It is dull grayish-brown in color, with short, pellucid bands between the veins of the wings. A greenish-colored variety of this species occurs in Utah. The ovipositor in this species measures a trifle over an inch in length. *Locusta occidentalis* is a smaller and more slender species said to occur in California. This is also fuliginous in color. *Locusta viridissimus*, the Great Green Grasshopper, occurs throughout Europe from Sweden southward, also in North Africa and Asia Minor. It lives on trees, bushes, and all sorts of plants, and is often found in grain fields. *Locusta caubata*, also European, enjoys a similarly wide range with the last-named species, and in Transylvania is quite common in fields of grain. A third species, *Locusta cantans*, is also very widely distributed both in Europe and Asia. Brunner von Wattenwyl, in his *Poodromus* of European Orthoptera, mentions an undescribed species of this genus as occurring in Japan.

The ACRIDIDÆ, embracing the locusts, is by far the largest family of the Orthoptera, and contains the most destructive of the insect class. It is perhaps unfortunate, as

having tended greatly to confuse the student, that the family name Locustidæ should have come to be confined to the insects of the preceding family, which are properly called in common language grasshoppers, katydids, etc., whereas the popular term locust is more correctly applied to the insects of the family now under consideration.

The Acrididæ reside for the most part on the ground, and are distinguished from those of other families of saltatorial Orthoptera by the following characters:—The antennæ are comparatively short, never exceeding the body in length, and as a rule composed of from twelve to twenty-five joints, though in a few species there are but seven or eight. The tarsi are apparently three-jointed. The abdominal appendages in the male are generally small and short, but the ovipositor in the female consists of two pairs of short, corneous pieces, one pair curving upward, the other downward, and together well adapted to drilling holes for the reception of the eggs. The male is without the stridulating organ at the base of the wings which is found among the Locustidæ. They nevertheless stridulate more or less perfectly, and principally by friction of the hind thighs against the hardened border of the elytra.

The eggs of locusts are elongate and cylindrical, and laid somewhat regularly in a mass in the ground,—the number varying from about thirty to a hundred and fifty or more, according to the species. Locusts occur in all parts of the world, and vary from one-fourth of an inch to four or five inches in length. They are either wingless or with well developed wings capable of sustaining flight for many hundred miles without resting. The transformations are essentially the same throughout the family, and details will be found in the ensuing account of *Caloptenus spretus*, our most injurious species.

For convenience, the family has been divided into minor groups or sub-families by entomologists; and the number and arrangement of these sub-divisions varies greatly with different authors. The Tettiginæ or Grouse-locusts are all small species in which the pronotum or thoracic shield is greatly enlarged posteriorly into a projection as long as or longer than the wings. These small locusts are most commonly found in low, wet meadows, and on the borders of water-courses, where their habits are very similar to those of the different species of *Tridactylus*, to which they bear a slight resemblance. They are very active and possess great leaping powers, but their dull, gray colors render them inconspicuous and often even quite difficult to observe. They hibernate under leaves and rubbish, either as pupæ or in the perfect state, and are among the very



FIG. 268. — *Tettix granulata*, granulated grouse-locust.

first of insects seen in early spring on sunny slopes after the snow has disappeared. *Tettix granulata*, or the Granulated Grouse-locust, is found throughout the northern portion of this country, where it reaches a latitude almost to the Arctic circle. *Tettix ornata*, which is a somewhat smaller species, is also widely distributed, having been taken in Canada, and as far southwest as Texas. *Tettix subulata* is an oriental insect. It is found throughout Europe from Lapland and Norway to the Alps. In these mountains it reaches an altitude of between nine and ten thousand feet above sea level. It also occurs sparingly as far south as Italy and Spain, and its eastern range extends far into the interior of Asia. All the species of this genus vary greatly in their color. A second and closely allied genus (*Tettigidea*) occurs in North America, the members of which are proportionately larger and more robust than those of the genus just described. *Tettigidea lateralis*, the female of which is about one-half inch, and the male one-third of an inch in length, is confined to the central and eastern portion of the

continent. It is of variable colors, ranging from dark brown to a dirty white above, and blackish beneath. The pronotum, which is comparatively smooth and marked with faint longitudinal striae, extends beyond the end of the body. *Tettigidea polymorpha*, which differs from the preceding species in having the pronotum as short or shorter than the body, has a like distribution, but is by far the more common species of the two.

Batrachidea differs from both *Tettie* and *Tettigidea* in having a more robust form, and in possessing a prominent carina or ridge extending along the middle of the pronotum. *Batrachidea cristata*, in which the carina is very prominent and regularly arched, is found throughout the eastern half of the United States, where it is chiefly confined to timbered regions. This species is gray, and often very beautifully mottled or marbled with various shades of brown and violet.

Intermediate between this group, and closely connecting it with the balance of the Acrididae, is a large, clumsy species, *Phrynotettie verruculata*, which is confined to the southwestern portion of the United States, where it lives along streams. This peculiar-looking locust measures about an inch and an eighth in length, and almost half as much in width, and is variably mottled with gray, brown, and black colors.

Throughout the southern portion of North America are found several very large and clumsy-looking locusts, which belong to the genus *Dictyophorus* of Brullé and *Rhombata* of Burmeister. These insects have the elytra and wings shorter than the abdomen, the antennae acuminate and somewhat flattened, and the vertex of the head pyramidal. *Dictyophorus cecutorio*, which is yellow and black, is confined chiefly to Florida and the adjoining portions of Alabama and Georgia, while *Dictyophorus marci*, which is almost entirely black, enjoys a much wider distribution. Both species measure about two and one-half inches in length.

The gigantic lobe-crested locusts of Central and South America, which are among the largest of insects, and some of which have a wing expanse of from eight to nine inches, live, as a rule, on bushes and trees. *Tropidueris darw*, which has the hind-wings brick-red, broadly margined with black, extends in its range from Panama to Texas. *Tropidueris ror*, which is a closely allied species, is said to occur in Equador, while both *Tropidueris latreillei* and *T. fabricei* are from Brazil. *T. cristata* is mentioned as inhabiting Asia and Africa, as well as South America. This last species is somewhat smaller, and has the hind-wings pale greenish-blue, margined and mottled with black, as in the preceding species. *Titanaeris carinata*, a West Indian species, differs from all of those belonging to the last named genus in the wings being immaculate. *Titanaeris albipes* is somewhat smaller, has a green band running from the apex to the base of the wings, and has the lobes of the pronotum round and smooth. In the genus *Lophueris*, of which there are three species, the wings are short, broad, and immaculate. *Lophueris offerii* is cited as occurring both in China and South America, while *Lophueris velasquezii* is from Vera Cruz, Mexico. *Lophueris humboldtii* differs from both of the preceding species in having the hind-wings pea-green instead of red. It is found on the west coast of South America.

The genus *Acridium*, to which some of our most common North American locusts belong, is a very extensive one, the species being mostly of large size, and including several that are migratory and destructive to vegetation. Like the crested giants just noticed, the species of *Acridium* are also inclined to be more or less arboreal in their habits. The different species are found throughout all countries that lie within the torrid and temperate zones. *Acridium perigrinum* is one of the true migratory

locusts of the Orient, and occurs also in portions of Central and South America. *Acridium shoshone*, a large greenish species with yellow antennae, is met with in the



FIG. 269. — *Acridium americanum*.

great interior basin between the Wasatch and the Sierra Nevada ranges, where it is most commonly found upon and in the vicinity of the small mountain oaks; while in the eastern half of the United States *Acridium rubiginosum* and *Acridium abutaceum* are both known to possess similar habits. *Acridium americanum* is one of our most common and handsome species, and, as will be seen by reference to the illustration, bears a close resemblance to the migratory species of the East. It sometimes assumes the migratory habit, especially at the south, where it becomes somewhat injurious to agriculture. Several other species of the genus are known to be truly migratory, in various portions of Asia, and neighboring islands. The species hibernate at times in the larva, or pupa state, but more often in the imago, or full-winged state. The genus has recently been disintegrated, and a number of new generic or sub-generic terms, of doubtful value, proposed.

The "Lubber Grasshopper," or the Clumsy Locust, of the plains, *Brachystola magna*, which we herewith figure, is a peculiar insect, confined to the central portion of North America, and is tolerably common on the western plains, where it slowly hops about, like a young toad, and shows a disposition to keep in the shade. It is a very awkward insect in its movements, and when disturbed, and caused to jump, it almost invariably turns a complete somersault, or alights upon its head.

A great many species of North American locusts belong to the genus *Caloptenus*. Several of these are known to be migratory at times, and one of them is habitually so. Most of the species prefer to live about vegetation, more or less rank and succulent, though there is considerable diversity of habit among them. While a few of the species are widespread and omnivorous, many others are local, and confined to particular food-plants. Of the former, *Caloptenus femur-rubrum*, the Red-thighed Locust, is found throughout North America. *Caloptenus atlantis*, a closely allied species, intermediate between it and the true migratory locust of this country, has an equally wide range. This species becomes very numerous and destructive at times, when it also exhibits the migratory habit in a limited degree. It is the species which has done the greatest injury in the New England States at various periods in the past. In parts of Oregon and Washington Territory it has also, at times, proved injurious. *Caloptenus differentialis* and *Caloptenus bicittatus*, our two largest species, are met with in low,

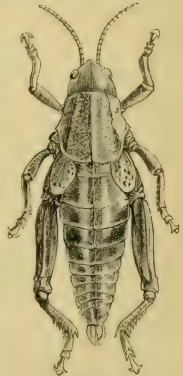


FIG. 270. — *Brachystola magna*, clumsy locust.

wet meadows, especially those in which rank weeds occur. The former is confined to the central portion of the United States, while the latter extends throughout the greater part of temperate North America. *Caloptenus luridus*, which closely resembles the common red-thighed locust, is met with in the Missouri valley, where it is more partial to uplands and more open country than are any of the preceding species. *Caloptenus cinereus* is found throughout the northwestern portion of the United States, where it lives upon several species of *Artemisia*, or sage brush, the leaves of which it resembles in color.

FIG. 271. — *Caloptenus differentialis*.FIG. 272. — *Caloptenus brevittatus*.

No insects have had more said about them, and none have done more mischief in the world than migratory locusts. They are distributed over all parts of the world which possess extended steppes or treeless plains. They flourish on elevated plateaux and in hot and dry atmosphere. They are essentially denizens of the plains, and cannot

perpetuate in heavily timbered or in low, humid regions.

The chief migratory species of the Old World, made famous alike from its terrible destructiveness and its frequent mention in Holy Writ, is the *Pachytylus migratorius*, which we herewith figure. *P. cinerascens* is but a variety. While this insect, together with other species, and especially *Acridium perigrinum* and *Caloptenus italicus*, have ravaged eastern countries from the earliest historic period, much remained to be learned, up to within a few years, whether as to its habits or as to the best means of controlling it.

The most injurious species in the United States is *Caloptenus spretus*, or the Rocky Mountain Locust, *alias* Western Grasshopper. It has ravaged the country west of the Mississippi, at irregular periods, from the earliest history we have of that country, and it was so very destructive in the northwestern States and Territories from 1873 to 1877, that it may truly be said to have been one of the chief causes of the business crisis which characterized that period. So widespread and disastrous were the results of its work that Congress provided for a commission to investigate it. As a result of the labors of this commission, the world has a better knowledge of these destructive migratory locusts—their habits, the laws governing their movements, their enemies, and the best way of dealing with them—than it ever before possessed. This information is embodied in the reports of the United States Entomological Commission, published by the government.

Caloptenus spretus being thus the best known of our locusts, in all its bearings, we will quote largely from our own writings upon it, because the general facts in reference to it will apply to all migratory locusts, while its development and transformations are typical of those of the whole family.

"No one who has not witnessed the ravaging power of locusts can fully conceive of or appreciate it. The organization and habit of the typical locust admirably fit it for ravenous work. Muscular, gregarious, with powerful jaws, and ample digestive and reproductive systems; strong of wing, and assisted in flight by numerous buoyant

air sacs,—all these traits conspire to make it the terrible engine of destruction which history shows it to have been under conditions favorable to its excessive multiplication. Insignificant individually, but mighty collectively, locusts fall upon a country like a plague or a blight. The farmer ploughs and plants. He cultivates in hope, watching his growing grain, in graceful, wave-like motion wafted to and fro by the warm summer winds. The green begins to golden; the harvest is at hand. Joy lightens his labor as the fruit of past toil is about to be realized. The day breaks with a smiling sun, that sends his ripening rays through laden orchards and promising fields. Kine and stock, of every sort, are sleek with plenty, and all the earth seems glad. The day grows. Suddenly the sun's face is darkened, and clouds obscure the sky. The joy of the morn gives way to ominous fear. The day closes, and ravenous locust-



FIG. 273.—*Pachytylus migratorius* (on the right variety *P. cinerascens*), old world locust.

swarms have fallen upon the land. The morrow comes, and, ah! what a change it brings! The fertile land of promise and plenty has become a desolate waste, and old Sol, even at his brightest, shines sadly through an atmosphere alive with myriads of glittering insects. . . .

"Falling upon a cornfield, the insects convert in a few hours the green and promising acres into a desolate stretch of bare, spindling stalks and stubs. Covering each hill by hundreds; scrambling from row to row like a lot of young, famished pigs, let out to their trough; they sweep clean a field quicker than would a whole herd of hungry steers. Imagine hundreds of square miles covered with such a ravenous horde, and one can get some realization of the picture presented in many parts of the country west of the Mississippi during years of locust invasion.

"Their flight may be likened to an immense snow-storm, extending from the ground to a height at which our visual organs perceive them only as minute,

darting scintillations, leaving the imagination to picture them indefinite distances beyond. . . .

"In alighting, they circle in myriads about you, beating against everything animate or inanimate; driving into open doors and windows; heaping about your feet and around your buildings, their jaws constantly at work biting and testing all things in seeking what they can devour. In the midst of the incessant buzz and noise which such a flight produces; in the face of the unavoidable destruction everywhere going on, one is bewildered and awed at the collective power of the ravaging host, which calls to mind so forcibly the plagues of Egypt.

"The noise their myriad jaws make when engaged in their work of destruction can be realized by any one who has 'fought' a prairie fire, or heard the flames passing along before a brisk wind, the low crackling and rasping — the general effect of the two sounds is very much the same. Southey, in his *Thalaba*, most graphically pictures this noise produced by the flight and approach of locusts:

"Onward they come, a dark, continuous cloud
Of congregated myriads numberless,
The rushing of whose wings was as the sound
Of a broad river, headlong in its course
Plunged from a mountain summit, or the roar
Of a wild ocean in the autumn storm,
Shattering its billows on a shore of rocks!"

"Nothing, however, can surpass the prophet Joel's account of the appearance and ravages of these insects. Omitting the figurative parts, it is accurate and graphic beyond measure:

"A day of darkness and of gloominess, a day of clouds and of thick darkness, as the morning spread upon the mountains; a great people and a strong; there hath not been ever the like, neither shall be any more after it, even to the years of many generations. A fire devoureth before them; and behind them a flame burneth; the land is as the garden of Eden before them, and behind them a desolate wilderness; yea, and nothing shall escape them.



Figs. 274 and 275. — *Caloptenus spretus*, Rocky Mountain locust, male and female.

The appearance of them is as the appearance of horses; and as horsemen, so shall they run. Like the noise of chariots on the tops of mountains shall they leap, like the noise of a flame of fire that devoureth the stubble, as a strong people set in battle array. Before their face the people shall be much pained; all faces shall gather blackness. They shall run like mighty men; they shall climb the wall like men of war; and they shall march every one on his ways, and they shall not break their ranks. . . . They shall run to and fro in the city; they shall run upon the wall; they shall climb up upon the houses; they shall enter in at the windows like a thief."

"The female, when about to lay her eggs, forces a hole in the ground by means of the two pairs of horny valves which open and shut at the tip of her abdomen, and which, from their peculiar structure, are admirably fitted for the purpose. With the valves closed she pushes the tips into the ground, and by a series of muscular efforts and the continued opening and shutting of the valves she drills a hole, until in a few minutes (the time varying with the nature of the soil), nearly the whole abdomen is

buried. The abdomen stretches to its utmost for this purpose, especially at the middle, and the hole is generally a little curved, and always more or less oblique. Now, with hind-legs hoisted straight above the back, and the shanks hugging more or

less closely the thighs, she commences ovipositing, the eggs being voided in a pale glistening and glutinous fluid which holds them together and binds them into a long cylindrical pod, covered with particles of earth which adhere to it. When fresh, the whole mass is soft and moist, but it soon acquires a firmer consistency. It is often as long as the abdomen, and usually lies in a curved or slanting position. It is never placed much more than an inch below the surface, except where some vegetable root has been followed down and devoured, and the insect leaves her eggs before emerging; in this way the mass is sometimes placed a foot below the

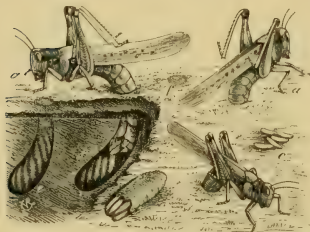


FIG. 276. — Egg laying of Rocky Mountain locust; *a a a*, female in different positions, ovipositing; *b*, egg-pod extracted from ground, with the end broken open; *c*, a few eggs lying loose on the ground; *d e*, show the earth partially removed, to illustrate an egg-mass already in place, and one being placed; *f*, shows where such a mass has been covered up.

surface. The eggs which compose this mass are laid side by side to the number of from thirty to one hundred, according to the size of the mass. They are 0.15 to 0.20 inch long, one-fourth as wide, slightly curved, of a pale yellow color, and rather larger at the anterior than the posterior end. As the hatching period approaches they become more plump and pale, and the embryo, with its dark eyes, is visible through the shell, which is now somewhat transparent. The opening to this egg-mass is covered up by the mother, but the newly hatched insect has no difficulty in escaping.

"The young locusts display gregarious instincts from the start, and congregate in immense numbers in warm and sunny places. They thus often blacken the sides of houses or the sides of hills. They remain thus huddled together during cold, damp weather. When not travelling, and when food is abundant, or during bad, rainy weather, they are fond of congregating on fences, buildings, trees, or anything removed from the moist ground. They also prefer to get into such positions to undergo their different moults. In fields they collect at night or during cold, damp weather, under any rubbish that may be at hand, and may be enticed under straw, hay, etc., scattered on the ground. Old prairie-grass affords good shelter, and where a wheat-field is surrounded with unburned prairie, they will gather for shelter along the borders of this last.

"The young locusts soon after hatching begin to display their migratory nature; but so far we have been unable to ascertain that they travel in stated directions as some persons have asserted. Our experience has been that different clusters of them have been noticed to travel in all directions at the same time.

"It is when they are abundant and vigorous enough to bare the ground of vegetation, and this principally after they are half-grown, that the habit of migrating in large bodies is developed. In 1877 scarcely any disposition to migrate was shown, and this was in strong contrast with what occurred in 1875. In a year like this last, when they are vigorous and abundant, their power for injury increases with their growth. At

first devouring the vegetation in particular fields and patches in the vicinity of their birthplaces, they gradually widen the area of their devastation, until at last, if very numerous, they devour every green thing over extensive districts. Whenever they have thus devastated a country they are forced to feed upon one another, and perish in immense numbers from debility and starvation. Whenever timber is accessible they collect in it, and after cleaning out the underbrush, feed upon the dead leaves and bark. A few succeed in climbing up into the rougher-bark trees, where they feed upon the foliage, and it is amusing to see with what avidity the furnished individuals below scramble for any fallen leaf that the more fortunate mounted ones may chance to sever. This increase in destructiveness continues until the bulk of the locusts have undergone their larval moults and attained the pupa state. The pupa, being brighter colored, with more orange than the larva, the insects now look, as they congregate, like swarms of bees. From this time on they begin to decrease in numbers, though retaining their ravenous propensities. They die rapidly from disease and from the attacks of natural enemies, while a large number fall a prey, while in the helpless condition of moulting, to the cannibalistic proclivities of their own kind. Those that acquire wings rise in the air during the warmer parts of the day, and wend their way as far as the wind will permit, toward their native home in the northwest. They mostly carry with them the germs of disease or are parasitized, and whenever they settle do comparatively little damage."

The larva upon leaving the egg and before shedding the amnion has the body soft and flabby; but as soon as this is shed it hops quite actively. "Belonging to an order in which the transformations are incomplete, the young locust differs but little in general structure from its parent. The most striking differences are the want of wings, and the less flattened, narrower prothorax, which rises from the sides more in the shape of a roof. The abdomen is also more roof-shaped. The perfect winged form is gradually assumed through a series of five moults, at the first four of which the wing-pads become more and more apparent, and at the last of which, from the pupa to the perfect state, the thorax becomes flattened, full wings are acquired, and the insect ceases to grow, except as the female abdomen becomes gravid and heavy with eggs. Yet with each moult, aside from the colorational changes, certain minute and less striking structural changes invariably take place, by observing which we may always know the comparative age and the particular stage of growth of any individual."

Like all creatures which suffer exuviation or the shedding of skin, our locust quits feeding for a while and remains quiet during the process. The first three or larval skins are almost invariably shed on or near the ground, the young insects congregating under grass in little hollows or depressions, or under any shelter that offers for the purpose. The cast-off exuviae are often very abundant in such sheltered places, and are not infrequently mistaken for dead locusts. The last two or pupal moults, on the contrary, more often take place above ground, the insects at these stages of growth preferring to fasten to some elevated object. Immediately after each moult the whole body is soft and colorless, as it was immediately after hatching.

"In order to illustrate the interesting process of moulting, we will trace an individual through the last moult — from the pupa to the winged insect — as it is the most difficult and, on account of the larger size of the animal, most easily watched. The other moults are very similar in mode of execution.

"When about to acquire wings the pupa crawls up some post, weed, grass-stalk, or other object, and clutches such object securely with the hind-feet, which are drawn up

under the body. In doing so the favorite position is with the head downward, though this is by no means essential. Remaining motionless in this position for several hours, with antennæ drawn down over the face, and the whole aspect betokening helplessness, the thorax, especially between the wind-pads, is noticed to swell. Presently the skin along this swollen portion splits right along the middle of the head and thorax, starting by a transverse, curved suture between the eyes, and ending at the base of the abdomen.



FIG. 277. — Pupa with skin just split.

“Let us now imagine that we are watching one from the moment of this splitting. As soon as the skin is split, the soft and white fore-body and head swell, and gradually extrude more and more by a series of muscular contortions; the new head slowly emerges from the old skin, which with its empty eyes, is worked back beneath, and the new feelers and legs are being drawn from their casings and the future wings from their sheaths. At the end of six or seven minutes our locust — no longer pupa, and not yet imago — looks as in Fig. 278, the four front pupa-legs being generally detached, and the insect hanging by the hooks of the hind-feet, which were anchored, while yet it had that command over them which it has now lost. The receding skin is transparent and loosened, especially from the extremities. In six or seven minutes more of arduous labor — of swelling and contracting — with an occasional brief respite, the antennæ and the four front legs are freed, and the full and crimped wings extricated. The soft front-legs rapidly stiffen, and, holding to its support as well as may be with these, the nascent locust employs whatever muscular force it is capable of to



FIG. 278. — The imago protruding.



FIG. 279. — The imago nearly out.

draw out the end of the abdomen and its long hind-legs. This in a few more minutes it finally does and with gait as unsteady as that of a new-dropped colt, it turns round and clambers up the side of the shrunken, cast-off skin, and there rests while the wings expand and every part of the body hardens and gains strength — the crooked limbs straightening and the wings unfolding and expanding like the petals of some pale flower. The front-wings are at first rolled longitudinally to a point, and as they expand and unroll, the hind-wings, which are tucked and gathered along the veins, at first curl over them. In ten or fifteen minutes from the time of extrication these wings are fully expanded and hang down like dampened rags. From this point on, the broad hind-wings begin to fold up like fans beneath the narrower front ones, and

in another ten minutes they have assumed the normal attitude of rest. Meanwhile the pale colors which always belong to the insect while moulting have been gradually giving way to the natural tints, and at this stage our new-fledged locust presents an aspect fresh and bright. If we now examine the cast-off skin, we shall find every part entire with the exception of the rupture which originally took place on the back; and it would puzzle one who had not witnessed the operation to divine how the now stiff hind shanks of the mature insect had been extricated from the bent skeleton left behind. They were in fact drawn over the bent knee-



FIG. 280. — Imago with wings expanded but not folded.

joint, so that during the process they were doubled throughout their length. They were as supple at the time as an oil-soaked string, and for some time after extrication they show the effects of this severe bending by their curved appearance.

"The moulting, from the bursting of the pupa-skin to the full adjustment of the wings and straightening of the legs of the perfect insect, occupies less than three-quarters of an hour, and sometimes but half an hour. It takes place most frequently during the warmer part of the morning, and within an hour after the wings are once in position the parts have become sufficiently dry and stiffened to enable the insect to move about with ease; and in another hour, with appetite sharpened by long fast, it joins its voracious comrades and tries its new jaws. The moulting period, especially the last, is a very critical one, and during the helplessness that belongs to it the unfortunate locust falls a prey to many enemies which otherwise would not molest it, and not infrequently to the voracity of the more active individuals of its own species."

This species continue to exist year after year for an indefinite period only under certain conditions, and hence is a more permanent resident of one section of the country than of another. These peculiar conditions obtain in the great Northwest where the country spreads out into vast treeless plains that have a comparatively high elevation and are dry.

There have been various theories advanced as to the cause of the migratory movements of this locust, but we should not look to any one, but to several causes that may either singly or combinedly produce the result. Were we asked for any single explanation or predisposing cause, we should answer, Excessive Multiplication; for the others are mostly secondary, or but consequences of this one. Among these may be enumerated hunger, the procreative instinct, annoyance by natural enemies, and possibly a true migratory instinct. In its flight the species frequently travels as fast as from twenty to thirty miles an hour, and single swarms have been traced over a stretch of country many hundreds of miles in length.

The genus *Pezotettix*, which is represented in this country by about thirty recognized species, differs from the preceding genus only in the abbreviation of the elytra and wings. Many of the species of *Caloptenus* have representatives in *Pezotettix*, the correspondences in all other respects being so close that it is difficult to decide whether the one should be considered merely a short-winged form of the other or whether it represents a permanent and distinctive type, and these facts indicate that *Pezotettix*, considered as a genus, has had its origin in arrested wing development of *Caloptenus*. The species of *Pezotettix* are, however, more localized in distribution and often chiefly confine their diet to a single or a special group of plants. They are, like the *Caloptenus*, partial to cool or shady localities, and hence are most frequently to be met with where vegetation is somewhat rank, as along the margins of streams and groves. They are also more frequent in mountainous than in level countries. *Pezotettix alba*, a greenish-white species, is found in Nebraska, where it lives solely upon a plant known



FIG. 281. — *Caloptenus speciosus*, Rocky Mountain locust, in flight.

in that region as white sage (*Artemisia*). *Pezotettix glacialis* inhabits the White Mountains of New Hampshire, while *Pezotettix dodgei* is found in the mountains of Colorado, both species being found above timber line. *Dactylotum pictum*, which is bluish-green with bright red and yellow markings, is found on the plains sloping eastward from the Rocky Mountains in Colorado, Kansas, and Nebraska. This is by far our brightest colored locust. It frequents sandy hillsides where the vegetation is short and somewhat scattered. *Dactylotum bicolor*, a closely allied species, is found in Mexico and California.

The genus *Stenobothrus* is composed of rather small species, and is well represented



FIG. 282. — *Stenobothrus maculipennis*: a, mature insect; b, pupa; c, larva.

in this country as well as in Europe. In these locusts the head is more or less conical in shape, with the face sloping obliquely backward. *Stenobothrus curtipennis*, which is very variable in color as well as in size, is confined to eastern North America; while *Stenobothrus occipitalis* inhabits the Rocky Mountain region. *Stenobothrus maculipennis*, which is here figured, is about the average size of the species of this genus. There are twenty-seven species recorded as inhabiting Europe, and about an equal number exist in this country. The

genus *Gomphocerus* differs from *Stenobothrus* in having the face less oblique and the antennæ slightly knobbed at their tips. *Gomphocerus clavatus* is an eastern species, while *G. aterpe* is confined to the prairies of the trans-Mississippi. *G. shastanus* is found in the mountains of the northwestern United States. The males of several species of this genus produce a loud rattling or hissing noise, somewhat resembling the rattle of the large gray rattlesnake, by rubbing the inside of the thighs against the elytra. The members of this and the preceding genus are most frequently met with on almost bare hillsides, where they bask in the warm sunshine in company with the various species of the genus *Ædipoda* and its numerous allies, of which this country contains upward of fifty species. These last named locusts are distinguished from those already noticed by their colored hind-wings, large head, and prominent eyes. The elytra, which are longer than the abdomen, are always more or less spotted and banded with various shades of brown and black, and the posterior femora are also banded and streaked. They hibernate for the most part in the perfect state. *Ædipoda* (*Dissosteria*) *carolina*, our most widely distributed species, is a large rust-brown insect, with black hind-wings bordered with yellow. It is most frequently seen along dusty streets and roads, where it may be observed balancing itself upon its wings in the air, and at the same time producing a rattling noise. *Ædipoda* (*Dissosteria*) *longipennis*, which is met with on the plains of Colorado and Kansas, differs in having the elytra pale and covered with numerous brown blotches, and in having the base of the hind-wing bluish. *Ædipoda* (*Hippiscus*) *phænicoptera*, the large robust locust of which a figure is here given, has the hind wings red, bordered with black. It is confined to the eastern half of the continent. *Ædipoda* (*Circotettix*) *carlingiana* and *Ædipoda* (*Circotettix*) *undulata* are species that are



FIG. 283. — *Ædipoda phænicoptera*, coral-winged locust.

confined to mountainous regions, where they frequent bare, rocky slopes. The former has the wings smoky-black, while in the latter they are yellowish. Both of these insects are very noisy — their clattering being much louder than that produced by the Carolina locust. (*Edipoda* (*Camuda*) *pellucida*, which in California is the injurious species, has the hind-wings pellucid yellow. Its habits are similar to those of *Caloptenus spretus*. It has been taken at various points throughout the United States, but is chiefly confined to mountainous districts, where it frequents meadows and wet places. *Edipoda* (*Pachytylus*) *migratorius*, the most destructive of Oriental species, has been so well described in the past that we need only refer to it here.

The locusts belonging to the genus *Tragocephala*, of which there are several representatives in this country, are very variable in color. They hibernate as larvæ and pupæ, and are found full-grown quite early in spring. *Tragocephala viridifasciata*, or the Green-striped Locust, which is green and brown, is found throughout the eastern portion, while *Tragocephala pacifica* is confined to the Pacific slope of North America.



FIG. 284. — *Edipoda pallucida*, California locust.



FIG. 285. — *Tragocephala viridifasciata*, green-striped locust: a, larva; b, adult.

There is an extensive group of this family in which the vertex of the head is greatly produced into a cone-like projection similar to that of the *Conocephalids* among the *Locustidæ* and *Platyblemmus* in *Gryllidæ*. These are chiefly confined to the warmer countries of the globe, where many of them are quite large. They have broad, flat antennæ, pointed at the end, and with their greatly lengthened heads are peculiar-looking insects. *Truxalis brevipennis* is a small, greenish species found in Florida. It measures about one and three-fourths inches in length. *Truxalis nautica*, which is a large species, is found throughout southern Europe, in Asia, Africa, and Australia. *Mesops chlorizans*, which is also green, is found in the Southern States. It has a very hard, smooth, and cylindrical body, the elytra are long and narrow, and the legs short. The female of this species is known to deposit her eggs in rotten logs and stumps. *Chrysochraon viridis*, a greenish species, in which the wings are also abbreviated, inhabits the eastern half of North America from the Great Lakes southward. The size of the female is at least twice that of the male.

The number of species of *Acrididæ* inhabiting the United States is about 275, while in Europe not more than about 180 are known.

C. V. RILEY.

ORDER VI. — HEMIPTERA.

This great group of insects, many of which are called Bugs, embraces a large assemblage of very diverse forms, apparently not closely related to each other, and having widely different modes of life. Their true composition is often disguised by modifications which have reference to some peculiarity of habit, or to stress of locality; but when these features are stripped off, there remains a basis of essential structure to connect all in one common group.



FIG. 286. — Under surface of *Cicada*, showing the rostrum.

Two principal kinds of structure pervade the series and serve to separate it from all other orders of insects. The first of these appears in the mouth-organ, concurrent with modifications of the head and breast (sternum). This instrument, the rostrum, consists of a horny, jointed, tapering tube, the labium, arising from the front of the head beneath, and enclosing four stiff bristles, the mandibles and maxillæ, adapted for piercing the tissues of plants or the skin of animals. By the aid of contractile muscles it imbibes the fluid nourishment suited to sustain the life of the insect. This rostrum is sometimes very long and slender, especially when the creature has to probe deep into the plant upon which it lives; or it is short and thick when the species finds food near the surface. The modifications of the sternum usually coincide with the form and use of the rostrum, and constitute a support for the movements of the head and its organs.

The second kind of structure appears in the organs of flight, the hemelytra or forewings and the hinder parts or wings proper. There are two principal types of the former which will be more fully noticed under the divisions Homoptera and Heteroptera. In general these are thick and leathery or crustaceous at base, and membranous at tip. In certain degraded forms, such as the bed-bug and lice, no wings are ever developed; while in the aquatic genera *Hygrotrachus* and *Limnotrachus*, there are individuals entirely unwinged, half-winged, or with fully developed hemelytra and wings.

The name of this order is derived from *hemi*, half, and *pteron*, a wing, having reference to the thick base and abruptly thin tip in the more commonly described division, the Heteroptera.

Scarcely any other great group of insects displays such a wide range of diversity as we see in this. Almost every pattern of form or style of marking to be found in the other orders occurs here, and that too with features of external structure not met with elsewhere. A few of these may be seen in the plate which heads this article. Besides the more prominent types of this order, which in North America is represented by the leaf-hoppers, tree-hoppers, cicadas, giant water-bugs, water-boatmen, wheel-bugs, chinch-bugs, squash-bugs, and plant-bugs, there is an almost countless host of small forms belonging to the scale-lice, plant-lice, and field bugs.

Among the terrestrial and more beetle-like forms, with broad oval and convex bodies, we notice the Pachycorids, Corimelanas, Stiretrids, Cydnids, and Pentatomids; those with elliptical bodies, flat above, belong to such groups as the Lygaeidæ and Coreidæ, while exceedingly depressed forms are present in the Aradidæ and Tingitidæ;

but in contrast with all of these are the thread-bugs, Emesidae and Berytina, whose bodies and members are as slender and delicate as the extremely attenuated crane-flies of the Diptera. Some are compressed and have the thorax raised high above the body in the form of a carrier's knife, or like a Templar's hat. Others imitate beech nuts, buds of trees, bits of dried leaves, scales of dead bark, and even the excrement of caterpillars.

This order is also rich in structural elements which serve to associate assemblages of genera in minor subdivisions easily recognizable. But it is difficult to arrange them all in one series, since there is often an addition of one or more elements binding them to small groups at a distance, and forming exceptions to the great balance of their affinities. The structure and position of the legs also vary with the mode of life of a species. Some are fitted for leaping, others for running, and still others for grasping tightly the objects upon which they rest.

Those which creep about in search of living prey are often furnished with curved or hooked fore-legs, suitable for seizing and holding creatures, when in motion, such as caterpillars and other larvæ. The anterior femora of many kinds which move about the branches and leaves of trees are set with numerous sharp thorns, sometimes in opposable rows, with which they transfix and hold their victims.

While the greater number derive their food from either the sap of vegetables or the blood of fishes, animals, and man, there are others which are satisfied with the strong fluid that accumulates beneath damp, decaying bark of trees, or still others which enjoy the juices of fungi or ferns. Among some of the highly developed forms, such as *Podisus*, *Stiretrus*, and *Rhopigaster*, there are species which live upon the juices of both insects and plants.

The Hemiptera are either aerial, terrestrial, riparian, or aquatic. Some pass their lives in the upper parts of trees, others chiefly on the lower limbs; still others prefer the protection of roots, stones, or rubbish on the ground; a large number of species select a home beneath the surface of the earth, often in the holes of ants or other insects; a conspicuous assemblage of dull-colored forms occurs only in the crevices or under the bark of trees and shrubs; while a host of others skim over the surface of placid waters, and a few are found remote from land upon the rarely disturbed waves of the tropical and sub-tropical oceans.

Their metamorphosis is incomplete, excepting only the males of the Coccidae and a few forms closely related to them. After leaving the egg they generally change the outer skin four times, at intervals of a few days each, to become adults. Growth is thereby permitted, the wing-pads and body become one size larger, and there is only a slight difference to be noticed between the young and the perfect insect. Nothing like a caterpillar stage appears in the newly-hatched creature, and there is no such differentiation as marks the larva, pupa, and imago of Coleoptera and the higher orders. The next stage to the adult is commonly called pupa, or nymph, but not because it is in any true sense equivalent to the pupa of other insects.

The head is either somewhat flat above and extended forwards nearly in the plane of the thorax, with the eyes seated in or next the base; or it is spindle-shaped, long conical, or cylindrical, freely movable, with the eyes placed considerably in advance of the base. In most riparian forms the eyes stand out prominently from the corners of the broad forehead. The aquatic species have the eyes either deep-seated in the basal angles, or projecting like beads on the sides of the vertex. In the Corixæ the head overlaps the front of the thorax like a cap, and is there attached by a slender neck, as

in Diptera and dragon-flies. Strongly in contrast to all these we find in the principal Homoptera a head either transverse or vertical, deep-seated, immobile, and prolonged downwards and backwards. In such exceptional groups as the Fulgoridae, the front of the head is either drawn out into a large inflated protuberance, is curved forwards in a long, tapering horn, or it is shaped like an Indian war club. Two, or at most three, ocelli are generally present, but they are absent in certain groups, such as *Pyrrocoris*, *Largus*, and *Capsus*.

The thorax constitutes a large portion of the mass of the body, and its first principal division is generally free, as in the Coleoptera. All three sections of this part of the body, the prothorax, the mesothorax, and the metathorax are well distinguished, and are only fused together in such low forms as *Aleurodes*, Aphidæ, Coccidæ, and the lice.

To these three pieces the legs are attached, not far out on the sides as in Orthoptera and Pseudoneuroptera, but beneath, and generally near the middle line. They are fitted for running, jumping, grasping, or swimming; and are often provided with curious balancing plates, curved thorns, waved lamellæ, or rows of spines. The coxæ are also built upon two principal patterns; the one being more or less conical and rotatory, the other more elongated, fixed, and only capable of motion in the direction of the longitudinal axis of the body. The tarsi have generally three or two joints, rarely only one. Generally there are four wings present, but the posterior pair does not appear in the males of the Coccidæ. The hemelytra and lower wings are developed from the sides of the meso- and metathorax; and in the Homoptera they are commonly attached lower down than in the Heteroptera.

A system of tracheal vessels conveys air to all parts of the body, and communicates with the outer surface by means of openings called stigmata. These openings are provided with a lid or contractile fold, which can be tightly closed to prevent suffocation. In a few of the aquatic forms, *Belostomatæ*, *Zethæ*, etc., they are apparently closed, but in reality have slit-like or valvular orifices which serve to strain the air and perhaps to admit only the oxygen that it contains. An air-chamber generally rests beneath each of the stigmata, and is connected with the others by tracheal tubes running throughout the length of the body on both sides. The stigmata amount in all to ten on each side; a pair is placed on the underside of each of the three divisions of the thorax, generally on or near the transverse sutures; six pairs are set beneath on the sides of the abdomen, and a pair is placed above next to the suture which separates the thorax from the abdomen. In *Fulgora* and its near allies these latter are very large, but are covered by a whitish fibrous secretion in the living insect. In the higher Heteroptera the abdominal orifices are capped by a little prominence resembling a bead, while in *Notonecta*, *Corixa*, and some *Cicadas* they are concealed by fur, hairy filaments, or scales. *Ranatra* and *Nepa* possess the usual number of stigmata, but have in extension a pair of long respiratory tubes at the end of the body through which they appear to receive most of the air required.

A variety of fluids and other substances are secreted by the Hemiptera. Some of these are for the protection of the body or the eggs, as in the Coccidæ; others, perhaps, for defence, as the annoying spray emitted by most of the Heteroptera. In many of the latter a most offensive bug-odor is characteristic of the fluid secreted by glands situated generally in each side of the body behind the mesosternum. Each of these glands communicates exteriorly with an orifice placed behind or near the middle coxa, called the osteole, which generally issues in some kind of an open channel styled the

osteolar canal, and this is surrounded by a more or less rugged and granulated space, the evaporating surface. The secretion is an ethereal oil variously combined, speedily dissipated in the atmosphere, and often having an odor similar to that of pears or other fruit. In some species of Coccidæ it is decidedly aromatic, and in a few it has a spicy smell very much like that of cinnamon.

These organs appear to be absent from the Homoptera; but most Cicadas secrete a powdery substance, scales, or hairy patches from the underside of the body, while the Fulgoridæ become covered beneath and on the end of the abdomen with a cottony or fibrous white substance. Some of the Coccidæ secrete wax or lac, and others various kinds of valuable dyes. The functions of nutrition are performed by a well-defined system of organs, of various forms, and often of remarkable complexity. Behind the mouth a short, distinct throat receives the fluid from two pairs of ducts connected with the salivary glands. From this the stomach is continued by an intestine-like tube, swollen in two or more places, until it reaches the vent. The first stomach, or gizzard, is a large, straight, frequently constricted glandular sac, narrowed behind into a long, flexed or convoluted canal (duodenum), also glandular, and dilated posteriorly into the chylic stomach; this is often continued backwards as a slender intestine (ilium), emptying into a colon-like expansion that terminates with the correspondingly wide rectum. Both of the intestinal parts of this organism are sometimes reduced to mere peduncles of the three pouched dilatations.

In the Cicadas, Tettigonids, and *Circopis* the first stomach is bent into a loop, and the duodenal portion runs off slender in convolutions and re-enters the stomach next the loop, the loop itself being attached to the œsophagus by a bundle of ligaments. The iliac portion, also long and convoluted, is attached to the other side of the loop and then runs backwards as usual.

The ovarian tubes vary greatly in number, and range from two to fifty or more in each aggregation, according to the species. In the same genus a wide disparity in the number of these organs frequently occurs. A large proportion of the Heteroptera possess five to seven; while the Cicadas have fifty to sixty, gathered into two large, rounded bundles; the Psyllidæ acquire about thirty, and the Coccidæ an almost unlimited number. In the latter they are arranged in two stellate branches.

Most of the eggs of the higher Heteroptera are ornamented with bands, or other patterns of color, and many of them are fluted, beaded, ribbed, etc. These also are capped by a toothed and movable lid, provided with a ligamentous spring to aid the emergence of the larva. The number of eggs laid by a single female varies also, not only with the species, but in the individuals. Some have been known to lay as few as twenty-five eggs, while the female Cicada sometimes deposits more than five hundred.

A well-developed nervous system appears in the adults, in general approaching that of the Coleoptera, being much concentrated towards the head in the principal groups. This is especially the case in the higher Heteroptera, where the cephalic ganglion or brain is massive, closely connected with the subœsophagial ganglion by two stout cords which pass below the gullet, and this in turn is immediately followed by the great thoracic ganglia, all three of these being fused together and continued some distance backward by a great nervous trunk. The brain often consists of a pair of distinct lobes, from which two heavy branches pass off to the eyes, more slender ones to the

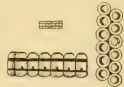


FIG. 287. — Eggs of *Strachia*, natural size and enlarged.

antenna, and one to each of the two or three ocelli. From the ganglion beneath the gullet the mouth-organs are supplied with branches, and from the thoracic ganglia and terminating trunk great branches run off and ramify upon all the organs within the cavity of the body.

The muscles of the Hemiptera are generally powerful and numerous, and are arranged chiefly with special reference to the movement of large organs of the body, such as the legs, wings, and head. Accordingly they are centred most in large bundles, in the three great chambers of the thorax, and almost fill the cavity of the prothorax.

Although these insects are not so numerous in species as the Coleoptera, Diptera, or Hymenoptera, they far outnumber the Orthoptera and Neuroptera, and possibly also the Lepidoptera. A large proportion of them have sober colors, agreeing well with bark, earth, rock, or other surfaces upon which they rest, and multitudes are easily overlooked because of their close resemblance to buds, processes, scales, and other objects that surround them; it is these peculiarities which have caused them to be difficult to recognize and have retarded their acquisition. But with the spread of more exact knowledge of their habits, a new impulse has been given to the study of the species, so that every expedition to unexplored regions returns with a quota of previously unknown forms.

At present about 27,000 species are known to be present in the private collections and public museums of Europe and America. These, including multitudes of undescribed species, are distributed in very nearly the following proportions: South America, 10,000; North America, 5,000; Central America and the West Indies, 2,000; Europe, 3,000; Asia and its islands, 3,000; Africa and islands, 3,000; and Australia, New Zealand, and the Philippines, about 1,000. But this must be far short of the actual number which can be found in these countries. Only in parts of Europe have careful and systematic searches been conducted for procuring all the species, and even there large numbers of new forms are discovered every year. So it may be safely estimated that scarcely more than one-half of the species of the globe have yet been accumulated, and that not less than 50,000 will be included in the more complete collections of the future. The hemipterous fauna of our own country is just beginning to be made known. Every part of its territory will yield new forms; and the zealous collector will be promptly rewarded with fresh novelties in many of the groups.

Like the Coleoptera they attain the largest size and most splendid colors in the tropics of both hemispheres. The largest form thus far described is the giant water-bug, *Belostoma grandis*, which lives in the fresh and brackish waters of Guiana and Brazil. It often measures fully three and a half inches in length by one and a quarter inches in breadth, and closely matches the muddy beds of the streams and puddles which it frequents. In the same countries, too, live the great lantern flies which measure six and a half inches across the outspread wings.

Some of the Scutellerids inhabiting Asia, Africa and the adjacent islands resemble the Buprestid beetles in form, and vie with them in the splendor of their metallic colors, which reflect the light in varying tints like polished copper or bronze.

In the vicinity of the Rivers Orinoco and Amazon, as well as about the great forest belts of Brazil, the species are more numerous and peculiar than in any other region on the globe. The large plant and tree bugs are there especially numerous, represented by the beautiful Pachycorids, Asopids, Pachylids, Meluchas and others, highly colored

and curiously marked with bands, stripes, or spots of red, orange, blue, or metallic green shagreened, and besides with one or more antennal joints flattened, and the first joint bent and spined, or with bodies invested with sharp spines in all directions. These are but a few out of the great assemblage of forms which tenant parts of the earth; but we shall take a nearer view of still others as we consider the various groups into which this great Order has been arranged.

SUB-ORDER I. — PARASITA.

At the very lowest verge of the Order we are confronted by an assemblage of small degraded insects which are the pests of man and animals. They are the haustellate Lice that have been removed from the ill-defined group Aptera of Linnaeus, and are now generally admitted to be Hemiptera of low grade.

As there are only characters of unfixed rank to separate them from the lowest Heteroptera such as *Cimex lectularius*, it is with difficulty that we follow Claus and other systematists in assigning to them a position of subordinal value. Professor Westwood has persistently retained them, together with the Mallophaga, which are mandibulate, have a flat labium and other differential characters, in a separate order styled Anoplura. But since he has himself recently described some forms which have the labium built after the type of a genuine heteropterous rostrum, coincident with an imperfect metamorphosis and general hemipterous structure, there is no longer a satisfactory reason for placing them outside of the Hemiptera. Mr. McLachlan has recently removed the bird-lice or Mallophaga to the Pseudoneuroptera, where they rest in relationship with *Termes* and *Psocus*; while the louse of the beaver has been relegated by Dr. Leconte to the Coleoptera; and the flea has long since been consigned to the Diptera.

Dr. Burmeister has made the commonly known human lice and a few others the basis of his first division of the Hemiptera, next preceding the Homoptera, giving them a value parallel to some superfamilies; and as no proper place can be found for them next to the Heteroptera, we follow his example, but begin the series with this group as a sub-order.

These insects have a tough, though thin outer integument of moderate flexibility, a flattened body suited for concealment at the roots of hair, fur, and bristles, and strong grasping retractile claws for climbing from one hair to another, or for grappling the cuticle with great tenacity. The transparency of their skin and the slenderness of the sutural impressions render the divisions of the thorax difficult to detect, but upon very close examination, aided by staining fluids, the three principal segments are always found to be present. The pieces of the abdomen are quite distinct, and two or more of the appendages of the anal segment may be easily recognized. A head of moderate size is set into the front end of the thorax, and is carried horizontally as in the Heteroptera.

Two prominent characteristics will serve to separate this sub-order from the others. The position of the ten spiracles is upon the upper side of the body, not beneath, and the legs arise from the outer margin of the thorax. These are accompanied by modifications of other values which will be recorded farther on.

The PEDICULINA is represented by very small, wingless, elliptical or lyrate insects with a fleshy unjointed rostrum, capable of extension by being rolled inside out, this action serving to bring forward a chaplet of barbs which imbed themselves in the skin

to give a firm hold for the penetrating bristles, arranged as chitinous strips in a long, slender, flexible tube, terminated by four very minute lobes, which probe to the capillary vessels of a sweat-pore. (Fig. 290.) The blood being once reached a current is maintained by the pulsations of the pumping ventricle and the peristaltic movements of the stomach. The legs are scansorial, armed with a long and powerful articulated curved nail at the tip of the tarsus, which is opposed by a toothed projection of the inner angle of the tibia.

Two genera at present compose this family, of which the first is *Pthirus*, with only one species, the Crab-louse, *P. pubis*. The body of this creature is lyrate, pale yellowish or white; the head deeply seated between the prominent shoulders of the thorax, with small, round, dark eyes on each side, five-jointed antennae, and chestnut-brown claws. There are four prominent processes on each side of the abdomen, beset with long bristles, the posterior pair being the longest and most slender. It is about three-fourths of a line in length, by one-half of a line in breadth. A marked difference from all the other members of this family will be noticed here in the form of the fore-legs. These lack the heavy claws of the other pairs, and have, instead, a slender tapering form with a very slightly curved tarsal nail. The effect is to give them more ready means of moving over flat surfaces, and of turning over if thrown



FIG. 288. — *Pediculus capitis*, head-louse.

upon the back. Their legs do not rotate freely upon the coxal articulations, and hence the claws must always be directed nearly downwards. These offensive vermin affect the pubic region and armpits of man; stretching themselves out flat, holding tight to the cuticle, and inflicting a most irritating puncture into the flesh of unclean and careless persons.

The other genus is *Pediculus*, which is represented by the common Louse of the human head, *P. capitis*, and the Body-louse, *P. vestimenti*. In these the thorax is quite distinct, narrower than the abdomen, with the head more or less conical and contracted at base. The eyes are usually placed on the sides, just behind the widest part of the vertex, but occasionally a little way inward from the margin; these are also simple as in the preceding genus. All the legs are armed with the claw-like nail and the opposable tibial spur, and in some forms there is a fleshy cushion between these instruments. The apparent number of abdominal rings ranges from seven to nine, and this part of the body is especially invested with a series of rigid bristles near the sutures and on the outer margins. Spiracles are conspicuous upon both the sides of the thorax and abdomen; those on the latter being sometimes placed far out next the margin.

In the first named species which is confined to the head of man we see a narrowly elliptical form, a little squared on the sides of the thorax; the margins of the abdomen more deeply scalloped in the female; the general color pale yellowish, with the outer edges of the thorax and abdomen dark brown or gray, and the nails pale brown. It is met with chiefly upon the heads of neglected children, where it lives among the hair, and to which it glues the oval eggs, attaching them mostly by the pointed end. These eggs are called nits, and under favorable conditions hatch in



FIG. 289. — Embryo louse; a, antenna; am, amnion; h, head.

about a week from the time that they are laid. At first the larvæ seem very translucent and delicate, but their skin speedily hardens and they move actively about to select a spot upon which to settle and suck the warm blood of their tender victim.

The second species, or body-louse, is somewhat larger and more slender than the preceding, the color is generally tinged with gray, the legs are longer and thinner, the head is more contracted behind, and the second joint of the antennæ is elongated. It is commonly about a line or somewhat more in length. It may be of some interest to notice that this is the form common to military camps in all temperate climates, as well as to careless persons who dwell in uncleanly apartments and who neglect to change their clothes. During the late civil war in the United States it was widely distributed by means of the railroad cars and other conveyances which transported troops. It affects the skin of most parts of the body, but especially selects the chest and back.



FIG. 291.—*Pediculus vestimenti*, body-louse.

The female attaches her eggs to fibres in the seams of undergarments, from which the larvæ hatch in about one week. Leewenhock has estimated that an ordinary female would produce about five thousand young ones within a period of eight weeks. In some countries of Europe, as Russia and Poland, this species is widely disseminated, and is by no means confined to the poor and degraded. It takes about one month for an individual to reach maturity; but the duration of life seems not to have been determined for any of the forms.

In the subgenus *Haematopinus*, which can hardly be separated from the typical *Pediculus*, various authors have placed the louse of the swine, also that of the horse, ass, buffalo, squirrel, etc. A form is found upon some of the large Asiatic monkeys that measures nearly one-fourth of an inch in length. Thus far about twenty-five nominal species have been referred to this family; but no doubt a host of others will yet be discovered when the various animals shall have been examined for this purpose.



FIG. 292.—*Haematopinus rituli*, louse of cow.



FIG. 290.—Rostrum of body-louse.

We now reach a group of the Parasita, which has lately been brought to notice by the publications of Professor Westwood of Oxford, the POLYCTENIDÆ. Certain bats of the genus *Molossus*, one inhabiting China, the other the West Indies, were found to harbor very peculiar lice of a type previously unrecognized. These have been described and figured in his beautiful *Thesaurus Entomologicus Oxoniensis*, from which we derive the following particulars: They have a long elliptical, or somewhat quadrate outline, with legs joined by rounded, free coxæ to the underside of clearly defined and well separated pectoral segments, the first pair short, stout, with three-

quadrate outline, with legs joined by rounded, free coxæ to the underside of clearly defined and well separated pectoral segments, the first pair short, stout, with three-

jointed tarsi and double nails, and placed nearer the sternal middle than the other two pairs, which are much longer and have longer four-jointed tarsi, also tipped with slender double nails. The head is large, somewhat quadrate, with a flat clypeus broadly rounded in front, and four-jointed antennæ, behind which are two profound reniform impressions armed with a row of comb-like teeth. The rostrum is three-jointed, nearly as long as the head, and has slender bristles extending throughout its length. The prothorax is large and transverse, and behind it are placed a pair of large scales, like rudimentary hemelytra. All parts of the body are well differentiated, and the transverse sutures both above and beneath are fringed with teeth or stout bristles.

Only one genus, *Polyctenus*, has yet been placed in this family, and it is only represented by the two species alluded to above. It may be recognized by the antennæ being longer than the head, composed of four joints, of which the first is angular at base, with one long bristle above and many bristles beneath. The rostrum has three joints and is dilated at base, and the tarsi are furnished on the end with a spinous cushion. The name was suggested by the rows of long, flat spines with which they are armed beneath the head.



FIG. 293.—*Polyctenus fumarius*.

The first of these species is the *P. fumarius*, which may be distinguished by the rounded clypeus, the head with two oblique impressions and prominent posterior angles; slender antennæ; a transverse thorax, with the sides a little rounded, and a long bristle in each angle behind; the hemelytra nearly quadrangular and armed with bristles on the posterior angles; the sides of the body nearly parallel; the legs with long bristles, and the nails of the posterior tarsi not very deeply cleft. It is about two-twelfths of an inch in length, and lives in Jamaica upon the bat *Molossus fumarius*.

Another species, the *P. molossus*, infests bats of the same genus in the vicinity of Amoy, China. It has shorter and thicker antennæ than the other, and the basal joint is armed with groups of strong spines; the posterior angles of the head are not produced, but the sides of the clypeus and the surface each side of the rostrum are likewise armed; there is also a curved double transverse series of flat spines on the trabecula behind the antennæ, and a fringe of longer ones on the hind margin; the prothorax is bean-shaped, armed on the posterior edge with short spines, and both the hemelytra and legs, as well as the abdomen of the female, are invested with short bristles. The legs are also stouter than in the other form. It is of the same length as the preceding, but is a stouter and more heavily built insect.

So remarkable and numerous are the various details of structure in this group of little creatures, that whole books might be devoted to an enumeration of peculiarities which would make them objects of wonder if they were of larger size. For further information, the reader may be referred to the beautiful iconographies of Piaget, Nitzsch, and Denny.

SUB-ORDER II.—HOMOPTERA.

This grand division of the order contains the greatest number of large species, and the widest range of diversity in the forms of all stages. Comparatively few are

destitute of wings, except in one sex of the lowest group; but some have these organs short and unfinished, and it is but very rarely that we meet with one of this kind fully winged. A striking instance of this nature occurs in the genus *Phylloscelis*, which has been based upon characters derived only from the uncompleted insects. In the chief forms of this sub-order the wings and hemelytra are large, slant downwards like the roof of a house, are of nearly equal texture throughout, although sometimes thin and transparent, and are numerous and continuously veined. A few notable exceptions to the decumbent position of these organs occur in such genera as *Flutoidea*, *Dusculia*, and *Helioptera*; while in *Pocilloptera* and *Ormenis* they are held nearly vertical.

This division is also remarkable for the blunt face, and backward-pressed elements of the head and breast, thus carrying the rostrum far underneath. These modifications are seen carried pretty far in Cicadas and Membracidae; although much disguised by the inflated or prolonged frontal protuberances in *Laternaria*, *Fulgora*, and *Mersia*.

Both kinds of eyes are generally present in this group; the compound ones being commonly large and prominent, while the simple ones, ocelli, are like little convex gems, placed between the larger eyes on the vertex or front; but occasionally, as in Fulgoridae, on the sides of the cheeks, between the latter and the antennae. There are usually two ocelli, although in Cicadidae and most Psyllidae they are three in number, and are placed in front, forming a triangle.

The antennae are usually situated in a hollow below the eyes, and are composed of a few expanded joints at the base, with a tapering, slender bristle-shaped termination. (Exceptions occur in Psyllidae, Aphididae, and Coccidae, where these organs are commonly filiform, and somewhat thickened at tip.) There are two principal types of legs in this division, although these are variously modified for particular modes of life: the one adapted for crawling, the other for leaping. The former have short legs, generally stout, as in the Cicadas and some of the Fulgoridae; the latter have the hind legs long, often curved and set with rows of stiff spines, such as we see in *Jassus*, *Tettigonia*, etc.

SUPER-FAMILY STERNORHYNCHI.

A very comprehensive alliance of usually very small and feeble insects presents itself at the outset of the sub-order, and forms an upwardly gradative combination leading to the truly representative Homoptera. It embraces the four families, Coccidae, Aleyrodidae, Aphididae, and Psyllidae, or the creatures generally known by the names scale lice, mealy bugs, bark lice, plant lice, and the Psyllas, or jumping lice. Their boundless fecundity and capacity for distribution fit them for the widespread injuries which they occasion in fruit-growing regions throughout the globe.

The name Sternorhynchi has reference to the rostrum, which apparently arises from the sternum between the anterior feet, and is the most characteristic element of structure which pervades the group. Divested of external disguises, the body of these insects is generally conical, either compressed, flattened, or pear-shaped; with filiform rather than bristle-shaped antennae composed of numerous joints.

Claus has erected these four families into a sub-order, and employed the name Phytolithires as a designation, but as this term was devised by Burmeister for a group including only the Aphidae and Psyllidae, we decline to wrest it from its original signification, and hence adopt that of Amyot and Serville instead.

In the family COCCIDÆ we reach the most anomalous forms to be met with in any part of the great class Insecta. Indeed, in many cases these creatures can hardly be said to have any particular form. The males are consistent in having one pair of transparent wings, of a generally obovate form, provided with a stout vein, which forks near the base and sends off one long branch near the costal border and another towards the posterior edge. Instead of hind wings they have a pair of halteres or balancers, each furnished with a hooked bristle, which fits into a pocket on the forewing of the corresponding side. This sex also lacks the mouth-parts which it possessed in its earlier stages; and it undergoes the final metamorphosis from a quiet pupal stage beneath the protecting scale. But the strange forms of the females have been, by reason of their resemblance to parts of plants and trees, a source of mistake and confusion to observers everywhere. These females soon pass from the active stage in which they began an independent existence, select a spot upon the twig or leaf of the food-plant, insert the slender rostrum into the bark, contract the legs and other appendages, and settle down for the remaining few months of their existence in shapeless lumps of waxy matter, in gall-like spherical bodies, or in oval or oblong flattened scales. In some of the species belonging to a division of this family, the Coccina proper, this sex preserves throughout the activity and somewhat the form of the larval stage. The above constitute the principal characters by which to separate this family from its nearest relatives, but as its subdivisions are peculiar in habits and metamorphosis, we must consider each separately.

The first sub-family to be noticed is named Diaspina from its principal genus *Diaspis*. It contains some of the most pernicious insects in existence, which, by reason of their vast multiplicity, ruin or destroy whole orchards of valuable fruit trees, or groves of shade trees. These are preëminently the scale lice. A familiar example may be cited in the Oyster-shell bark louse of the apple, *Mytilaspis pomoran*. As its name implies, it is of the shape of a narrow, curved mussel or oyster-shell, about one-twelfth of an inch in length, bluntly rounded on the broad end, of a dull, horn brown color, tinged with gray, with the projecting edges of the exuvie more or less yellow, and with the body yellowish-white. The scale of the male is smaller, of the same general color, but straighter, and having the posterior division hinged to the forward part by thinner integument.

This species has been introduced into the United States from Europe, and has been found more hurtful to apple-trees in the Northern and Middle States than in the South. It is also said to be single-brooded in the former and double-brooded in the latter. In the latitude of Maryland the eggs begin to hatch in April or May, according to the forwardness of the season, and continue to do so until warm weather is settled early in June. Countless multitudes of these dark scales, packed together as close as they can lie, may be seen upon twigs and small branches of the trees in neglected orchards. The bark is made rough by their thickly strewn bodies, and takes on the appearance of wrinkles, where they are very numerous. The eggs, when freshly-laid, are of a flesh tint, but become white after maturing, and the number beneath the female scale varies from about twenty-five to three or four times that number. When ready to hatch, the body of the young insect shows through the skin of the egg, and gives it a yellowish tinge.

It has not been my good fortune to breed the male, but Mr. Riley describes it as "translucent carneous-gray, with bands of purple-gray on the back of each ring of the abdomen, and with portions of the mesothorax and metathorax of the same color,

while the legs and antennæ are paler. The last named organs are ten-jointed, and have the first two joints bulbous."

The female scale forms a covering for the eggs and protects them from the rain and severe weather of winter. When fresh from the eggs the young are very soft and tender, provided with six distinct legs and capable of moving freely about. If the weather is warm they soon leave the mother scale and crawl about in search of a tender place on the bark or twig, into which they pierce their rostrum and become forever fixed. Should the weather on the contrary prove cold and blustery they remain beneath the scale, sometimes even for two or three days, until impelled by hunger they scatter all over the branches and buds. At this time they are scarcely more than one hundredth of an inch in length, about three times as long as wide, pale yellow with a deep yellow spot in front and another near the end, the sides somewhat fringed with short hairs, and the tip of the abdomen set with two stiff bristles, between which are placed a pair of spinous hairs.

After becoming fixed they steadily secrete the scale under which they rest, gradually becoming darker and harder, until by late summer they have attained their full size, lay the eggs underneath the scale, and die. By this time the female has become scarcely more than a bag of eggs, and the body has shrunk into a small particle at the narrow end of the covering.

The scales of the male are few in number, of small size, and are fixed either upon the upper or lower sides of the leaves. No specific differences can be made out in comparing the scales of those found upon the apple with others which are found common upon the maple, linden, and a great number of other shade trees in and near our large cities of the Middle States. But as the males of all these have not yet been compared, no decision can be reached as to their identity.

Turning to the next sub-family, the *Lecanina*, we find native and foreign forms which live on the branches and leaves of trees and plants as in the preceding subdivision. They are equally pernicious to vegetation, and embrace many tropical or sub-tropical forms which thrive in our hot-houses.

The species of this group, according to Doctor Signoret, are either naked, inclosed, or covered with waxy or cottony secretion, and are of very various forms. Some are either gibbous, hemispherical, convex, warty, barnacle-shaped, or like little pellets of cotton capped in front with a brown scale. There are also other kinds which resemble the small marine shells of the genus *Tricia*, or the round smooth galls of various oak leaves. Such of the males as have been observed possess an angular head with a number of eyes and ocelli, varying from four to ten, placed in front, behind, and upon the sides, and have also stout, hairy, ten-jointed antennæ.

As representative of this division we may remark the depressed scales of the *Lecanium hesperidum*. It is a great pest to greenhouse florists, abounding upon the orange, lemon, ivy, and numerous other plants. In the latitude of Washington and farther south it lives upon a great variety of plants in the open air,

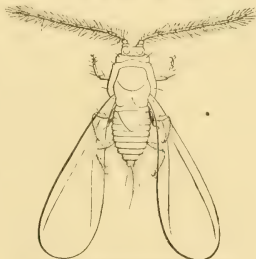


FIG. 294. — *Mytilaspis pinifolia*, pine leaf
Mytilaspis, male.

and it is equally abundant upon oranges and a few other plants in the south of Europe.

The female scale is wax-yellow, darker upon the disk, of a long oval shape, smooth and shining, rather flat, with a few scattered punctures on the back, the antennae seven-jointed, the fourth and seventh joints nearly equal in length, and the last segment of the abdomen very small and furnished with six long, stout bristles. It is also viviparous. The male has not yet been discovered, although the species has been widely known ever since the time of Linnæus. It is the commonest and most extensively distributed form of this group, being known wherever civilized man has introduced plant-houses. The full grown scale is about one-eighth of an inch in length, and when dried becomes wrinkled along the margins, and rests very closely in contact with the surface of the leaf.



FIG. 235.—*Lactinium*, upper and under surfaces.

Besides those which are hurtful to trees, there are others of great value to commerce and the arts. The *Carteria lacca* of India yields the lac which is melted into cakes and small sticks ready to be sold in the stores, and is employed in making varnishes, sealing wax, water-proof surfaces, dyeing, etc. It is the puncture of the female which causes this resinous substance to exude from the twigs, and this, after having been collected from the banyan and other trees upon which the insect lives, is selected, pounded, and the mixed coloring matter extracted by water. It is also melted, strained, and formed into thin flakes or thick masses. This important insect which secretes an exquisite carmine lake, is the veriest pigmy of its group, being no more than the one thirty-sixth of an inch in length when full grown; but it appears in vast numbers upon the trees in the province of Bengal, as also in Siam, Assam, Malabar, etc., and is thence exported to all parts of the world. The body of the dried female is red, with very hairy six-jointed antennae, four eyes, and no ocelli. The legs remain quite distinct, are stout and hairy, with the tibiae one-third longer than the thighs. To avoid contact with the resinous secretion caused by its puncture the insect is enclosed in a kind of woody gall, of form varying with the age and sex. That of the female appears globular, while that of the male is oblong. In the crude lac of the shops these are found mixed with the bodies of both sexes, often broken into pieces and with a predominance of the young ones.

To this group also belong the wonderful forms of the genus *Ceroplastes*. These are all tropical or sub-tropical forms, one species only of which overlaps into the western territory of the United States and occurs in Arizona; while two or more forms occur in southern Florida. Cuba and the larger West India islands afford a number of species of this genus, some of which are very remarkable for their form and structure. The female of one of these is shaped like a box tortoise, and has the outer integument divided into impressed spaces similar to a mosaic pavement. Its body is so well concealed by this outer covering that it can only be detected by the closest scrutiny.

Ceroplastes rusci of Southern Europe has been described by various authors, and more recently by Dr. Signoret in his classical "Essai," who takes it from *Lecanium*, to which it had been previously referred, and shows its affinity to the present genus. It has the form common to the species cited above, is of a grayish white color, with a central convex disc, surrounded by a marginal row of eight variously shaped plates,

giving it a tessellated appearance similar to the plates on the back of the common box tortoise. About fifteen or sixteen species are known, which have been obtained from almost as many regions of America, Africa, Europe, Asia, and Australia. These all have a more or less waxy covering for the protection of the body in the female, and this substance has been employed to some extent in the fine arts.

A peculiar form hitherto found only in the United States stands in great contrast with all of the above, and as a conspicuous member of this family deserves to be noticed. It is the *Pulcinaria innumabilis* of recent authors, and was first made known by Mr. S. S. Rathvon, of Lancaster, Pa., who discovered it in great numbers upon linden trees growing in that city. It has been since found in many parts of the middle, northern, and northwestern states, more commonly upon the soft maple. Mr. Putnam of Davenport, Iowa, made a special study of its life history and structure, and by his patient labor has given a fuller account of this species than exists of any other of our North American forms.

During some years it is exceedingly abundant upon the maples lining the streets in the city of Baltimore, and forms a conspicuous object projecting from the twigs and leaves. When fully developed it is one-fourth of an inch in length, resembling a little ball of cotton floss, with the dark dried scale on the front, and when settled in closely packed patches it gives the limbs of trees an appearance of being loaded with pellets of loose cotton. A close examination of this cottony mass in the month of May disclosed multitudes of exceedingly minute, white eggs entangled all through it. In about three weeks the eggs appear somewhat darkened in color by the embryo showing through the transparent shell and begin to give forth the young larvae. These are active little creatures, with six legs, and of an elongated oval form, rather depressed and sharp-edged. They soon find a place upon which to settle, either upon the twig or leaf, and after withdrawing their slender rostral bristles from the loop in the abdomen, thrust them through the tender bark and become fixed for the remainder of their short lives.

Advancing a step farther we reach the most important group of this family, the true Coccina. Here we have forms which preserve the distinctly segmented body and capacity for motion throughout all stages of their existence. In other words they are a grade higher than either of the other alliances. In only a very few species do they become covered by a hardened scale and fixed to a single spot; but because of these exceptions a modification of the terms distinctive of the sub-family becomes necessary, and thus the group is limited by only a very small number of characteristics. The principal of these is found in the many-jointed labium of the female, besides the persistent distinctness of the segments alluded to above. In this sex also the antennae are composed of from six to ten joints in the adult, and six only in the larvae.

The adult males differ from *Lecanium*, chiefly in having shorter attachments to the body, with large wings and three-jointed poisers. In a few species the wings are absent.

To this sub-family belongs that important and precious insect, the *Coccus cacti* of authors, which yields the highly prized Cochineal of commerce. This is the most valuable insect in existence, and has superseded in large measure the use of various other species of this group, some of which had been employed as a dye from a period dating back to the time of Moses. The Phenicians were famous for the rich red of their garments, and it is no doubt due to their acquaintance with the Kermes of the Mediterranean borders that they were able to obtain such celebrated crimson and scarlet dyes.

The insect which constitutes the cochineal is an unattractive plump, oval, dull purplish-brown object, about an eighth of an inch in length, covered, when alive, with a cottony secretion which hides the rings of the body. When dead and dry this cottony substance rubs off and leaves only vestiges in the form of whitish powder. It is the female only that is so constituted; for the male is a smaller, slither, gay red insect, with a pair of whitish wings, four dark, smooth eyes, and two ocelli. His antennae are composed of ten joints each, and the two at the base are armed with one or two little bristles.

This species was first discovered in Mexico and was carried thence to Spain, and by the French introduced into Algiers, where extensive nopalaries have been established

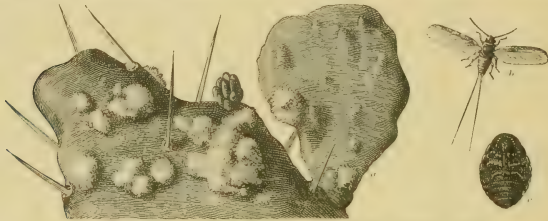


FIG. 296. — *Coccus cacti*, cochineal, a, living on cactus (*Opuntia*); b, male; c, female.

for its cultivation. It swarms upon several kinds of Cacti; but especially upon the *Opuntia coccinifera*, which is cultivated expressly for the purpose of feeding and developing the insect. Such quantities of the cochineal insects are produced in Mexico and Peru that Humboldt estimated the amount annually brought to Europe to exceed 800,000 pounds, each pound containing about 70,000 of these insects. England alone has been known to consume in a single year 150,000 pounds, valued at £375,000. It is also not uncommon upon wild cacti in Texas and Florida, and occasionally may be found upon these plants in our hothouses.



FIG. 297. — *Coccus adonidum*.

Many other remarkable forms belong to this extensive family, but we can only mention two or three more. One of these is the *Gossyparia mammipara* of Mount Sinai, and other parts of Arabia, which gives rise to the manna of commerce. This it does by puncturing the tender shoots of the tamarix tree, causing an exudation of sweetish gum which, when hardened, drops to the ground in small pellets, and is then gathered and packed for transportation.

Another is the curious "Ground Pearl" of the Bahama Islands. It lives beneath the soil in crevices frequented by ants, and acquires a shell-like, calcareous scaly covering, which has caused it to be mistaken for the outer case of a mollusk. It is used by the natives for necklaces, and is accordingly arranged on threads like strings of beads. The original describer of this species called it *Margarodes fornicarum*, in allusion to its pearly appearance and habit of living in company with ants.

A third is the anomalous genus *Orthezia*, which inhabits both Europe and the United States. It is composed of four species of insects, ranging from about one-

sixteenth to one-eighth of an inch in length, all of which agree in having the body covered by three or five series of flakes of chalky fibrous substance, which is drawn out behind into flat bundles of long compacted filaments, like feathers in the tail of a fowl.

The largest insect of the whole family, *Ortonia uhleri*, is a somewhat bean-shaped thick object, more than one-half of an inch in length, densely covered by a white powder, which hides the segments of the body as well as the legs. It was found upon trees in the desert of Napo, six thousand six hundred feet above sea level, at a distance of about one hundred miles east of Quito. Only females were discovered, and nothing more is reported of its habits than that it lives upon the trunks of high trees, in groups rendered very conspicuous by their uniform white coating.

More than five hundred species of these curious insects have already been made known, and every year brings its quota of newly discovered forms, or adds new facts in the life history of those previously described.

The family ALEYRODIDÆ is composed of very small insects, with large, broadly oval, delicate wing-covers and wings, which in repose are carried nearly horizontal. The ground color of these is dull white in most of the species, and there is one long forked vein running along the middle and bent at tip; back of this two indistinct, short veins run out from the base. Their head is small, having divided eyes; the antennæ are short, six-jointed, and the rostrum has only two joints, of which the basal is the longest. The legs are short, simple, with two-jointed tarsi furnished with two nails. They are exceedingly prolific, and in the larval state are scale-like and fixed to leaves like members of the genus *Lecanium*. Both sexes undergo metamorphosis beneath the scale.

The only genus in the group is *Aleyrodes*, and it is composed of about twenty-five nominal species, whose life history is but imperfectly known.

In the United States there are several undescribed species, which may prove to be only local forms of those already made known in Europe. The most common one in the Atlantic States is the *A. corni*, which has a yellow body, black eyes, and white, powdered wings without spots. It measures about one-tenth of an inch across the expanded wings; and is found adult during September and October, beneath the leaves of *Cornus sericea*.

We now come to the family ARHIDIDÆ. Any one who has ever given attention to the raising of a few geraniums or garden plants, must have noticed upon the stems or leaves of some of them small green or greenish and black, soft-bodied insects, settled in crowds, steadily engaged in pumping the sap through their thread-like rostrum. These are the plant-lice so widely known as the pests of the farmer, gardener, and vineyard cultivator.

They constitute a numerous tribe of little, sometimes minute forms, generally more or less pear-shaped, often gayly colored and ornamented, and when winged having two pairs of thin, membranous wings, charged with a few simple veins. The upper pair of these is much more ample than the others, and has the long costal areole marked off behind by a thick ligamentous vein, which greatly stiffens and strengthens them for flight; but in the hind-wings support is gained by the forking at tip of the principal longitudinal vein, and by little hooks on the front edge catching into the posterior marginal reflexed expansion at the base of the fore-wings. Both pairs of these organs



FIG. 298. — *Aleyrodes*, pupa and adult

are remarkable for being attached to the mesothorax, and never to the metathorax, as in other Homoptera. Here, as in the Coccidae, the mesothorax is much the largest



FIG. 299. — *Aphis*.

segment; the prothorax is usually little more than a ring closely compacted against the former, while the metathorax is a very small segment rendered inconspicuous by the base of the abdomen. Accordingly, in the winged individuals, the hind-legs are set pretty far back, as if they arose from beneath the abdomen, but in the unwinged the legs appear closer together; the hind ones being often conspicuous for their length and thickness.

On each side of the head a prominent round eye is placed, against which may be observed a tubercle or supplementary compound eye, and besides these there are three, rarely six, ocelli

variously situated on the vertex between the antennae. Most species which live beneath the surface of the ground have neither eyes nor ocelli. The antennae are usually long, in a few very short, slender filiform, thicker at base, and composed of a variable number of joints, never less than three nor more than seven. The rostrum is a slender, three-jointed organ, of variable length, in some genera such as *Lachnus* and *Schizoneura*, it is longer than the abdomen, and projects behind like a tail.

Typically there should be eleven rings to the abdomen, but only nine are conspicuous; and the stigmata are placed on the underside as usual, but difficult to detect. These latter are of very simple structure, have either a circular or oval orifice, consist of ten on each side, and are kept open by a horny ring. On the upper side of the sixth abdominal segment there is usually a pair of cornicles or slender tubes, often of considerable length, composing the sheaths of excretory ducts, which pour forth a sweet liquor at the pleasure of the insect.

In some genera, such as *Lachnus* and its allies, these organs are merely perforated tubercles, while in *Phylloxera*, and some other low forms, they are entirely wanting. Attached to the end of the ninth abdominal segment there is usually a little slender process called the *cauda*, or tail, which, by its numerous modifications, affords excellent distinctive characters for grouping the species.

Unlike the members of the preceding family, the plant-lice are active in all their states, and in general present a similarity of appearance, which even in the unwinged and young forms would serve to distinguish them from all other insects. This agreement is most noticeable in their generally flask-shaped bodies, crowned by a truncated head and puffed face, the latter feature recalling that of some members of the Pseudoneuropterous family Psocidae. When quite young they are often narrower, and of a more or less quadrangular form; while the winged females are less broad and stout than the unwinged ones.

One great feature of their economy has made them the wonder of all observers from the time of Reaumur, who first gave an extended account of their history, to the present. But it is to the patient and laborious investigations of Bonnet that we are indebted for the discovery that these little creatures are capable of indefinite propagation without the intervention of the male. This well-known observer studied individuals of several species from hour to hour for a period of five months, and recorded every

change which took place in their daily lives through all that time. They were his pets, and absorbed his attention as thoroughly as if they belonged to some higher group. He informs us that he took precautions to isolate a single female plant-louse at the beginning of her young life, and to follow her through to the end. He found that she changed her skin four times within a period of nine days, and was then a full-grown insect. On the tenth day she deposited a living young one, and each day continued to add others until, at the expiration of three weeks, ninety-five little ones had been brought forth. Pursuing the subject, he found that these young ones grew up and also brought forth living young, and these in turn others, until by the end of the third month he had secured five distinct generations of plant-lice, each like the original mother. He was not satisfied to stop there, but repeated the experiments with other and widely different species which lived upon dissimilar plants. This he continued to do until the return of cold weather, in November, when he found that both sexes were finally developed, which united for the production of fertilized eggs.

Later investigators have pursued this subject still farther, and have shown that the fertilized egg laid in the autumn hatches out, about the time of leaf-budding, in the following spring, a female stem-mother which starts anew the life-cycle of her species for the remainder of the year.

The three stages of existence, usually called larva, pupa or nymph, and imago, the adult insect, are scarcely as distinctly marked here as in the higher families of the Homoptera, and in the unwinged forms there is no appreciable difference but size to separate the intermediate stage from the adult.

From recent verifications of the investigations of older authorities, we are enabled to state with confidence that there are winged females which produce only living young; that very rarely has the winged female been found to lay eggs; that un-winged females produce living young, which are either winged or unwinged, and that at the return of cold weather a brood of wingless females arises, which unites with winged males and deposits fertile eggs. The male appears late in the season, and in the species which live above the earth is almost always winged. Exceptions to these statements will be found in some of the lower forms, such as the *Chermesina* and their near allies, where the oviparous females are either winged or unwinged in the same cluster.

Not only do we find such differences of nature among the sexes, but besides these there is also sometimes an important modification of form, as well as color, within the limits of a cycle of generations. Thus in the European *Chaitophorus aceris* two kinds of larvae are developed and brought forth at nearly the same time. The one is a normal Aphis, similar to its mother, of a brown color, and garnished with little tufts of hair; but the other is bright green, with a broad head, lobate behind and fused with the thorax, the back and sides decorated with four series of plate-like attachments, which give the insect an appearance somewhat like the carapace of a tortoise. Instead of the hairs seen in the normal young, the margins of the body and the limbs are furnished with a series of flat transparent leaflets, in which ramify a system of radiating vessels. Similar folioles also arise from the basal joint of the antennae, and more slender ones sprout from tubercles on the end of the venter. Not being gregarious like its sisters, it remains solitary, fixed to the inner angles of the leaf-ribs of the sycamore or maple, and so continues for the four months or more allotted to its existence.

Dimorphism of such an abnormal character is scarcely to be met with in any other group of the insects; and it is especially striking here, occurring as it does in the

midst of forms which are not more variable than many others of the typical aphides. More than two patterns of form are stated to occur in the *Phylloxera* of the grape-vine, and hence it is said to be polymorphic. In many species of the true plant-lice it is now well established that there are two types of the same insect, the one inhabiting the roots, and living there during the colder part of the year unwinged, the other inhabiting the leaves and twigs throughout the spring and summer. This is notably the case with a small black aphid which injures, and even destroys, the peach-trees of eastern Maryland, Delaware, and New Jersey. Other examples may be cited, such as the Woolly Aphis of the apple-tree, *Schizoneura lanigera*, the Maize Aphis, *A. maidis*, and the Grape Gall-louse, *Phylloxera vastatrix*.

On the other hand, M. Lichtenstein, of Montpelier, France, has recently made and verified some remarkable discoveries with regard to the plant-louse of the European elm, *Tetraneura ulmi*. He finds that this species, which produces little smooth green-stalked galls on leaves of the elm, lives during its subterranean budding phase on the roots of maize in Austria and Hungary, and in France on the roots of the dog's-tooth grass. As late as the 10th of December he still found the wingless form alive upon the roots, showing that "side by side with the winged form, which gives rise to the sexual reproducers, there is an uninterrupted sequence of subterranean organic reproduction, so that should any circumstance happen to destroy the winter-egg, there would be always a subterranean provision ready" to replace the unfortunate sexual generation. Besides this the mother does not expel the winter-egg, but keeps it protected within her dried skin, settled deeply in a crevice of the bark of the tree.

Morren tells us that the plant-louse of the apple tree produces one hundred young ones in a single generation, and that each female of these brings forth others just as numerous, so that by the completion of the tenth generation, which takes place before the advent of cold weather, the original individual has become the mother of one quintillion of her species. From this we can gain an idea of the countless swarms of these creatures which arise from the multitudes of eggs which are found sticking in cracks and wrinkles of the bark, twigs, and buds of every kind of plant and tree.

Occasionally after a mild, dry winter they become more numerous winged than usual, and in such a case become overcrowded, migrate to other localities, and fill the air with their dense swarms. This has occurred in notable instances, when whole crops of cereals and vegetables have been destroyed by their combined attacks. Nearly all of the aerial species have the power to secrete and expel from their honey-tubes a sweet fluid, which serves to nourish the young shortly after they are born. It is this liquor which so greatly attracts the ants and other insects, so that the former may often be seen coursing over the branches and twigs in search of aphides, and, when found, stroking them with the antennæ, thus causing them to give forth a drop of the substance, which they greedily lap.

In the southern and central parts of North America little colonies of brown or yellowish plant-lice may be seen congregated in almost every underground ants' nest. There the ants carefully tend them, protect their eggs, secure to them a comfortable home where they can enjoy the sap of the tender roots, and are then rewarded by the sweets which flow forth at their bidding.

The family as now constituted includes four sub-families, Aphidina, Pemphigina, Rhizobiina, and Chermesina, of which the first and second include the largest and most conspicuous forms, and those which are most commonly seen about the farm and garden. Among the former, the genus *Lachnus* embraces the largest and most

showy species of the entire group. It may be recognized by the shorter antennæ, composed of six joints, the last one often ending in a spur much like a supplementary joint, and by having the fourth vein of the fore-wings nearly straight, the stigma linear, and the body coated with white powder.

Lachnus coryæ is a showy form, about one-fourth of an inch in length, of a bluish slate-color, with four transverse rows of black dots, reddish thighs, no stylet to the venter, and only very short honey-tubes. It dwells in loose clusters on the twigs of the pignut hickory, and is seen fully winged in the autumn. This species is in marked contrast with the common garden or field forms of the aphides, which are generally glossy, more flask-shaped, delicately built, with green, yellow, or black bodies, and long, seven-jointed antennæ.

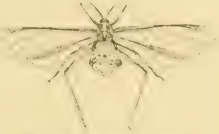


FIG. 300. *Lachnus punctatus*.

In the Pemphigina the body is obese and blunt, clothed with cottony secretion, the honey-tubes small or absent, the antennæ short and six-jointed, the fore-wings with only one fork to the third discoidal vein, and the hind-wings with one or two oblique veins. They live chiefly on bushes and forest trees, a few only on fruit-trees.

The Chermesina have only two discoidal veins to the fore-wings, and the antennæ are usually composed of five joints, but exceptionally of only three. This group includes the dreaded Phylloxera of the vine, and is composed of very small insects, usually of a black or yellow color, living upon different kinds of forest trees in Europe and North America.

As the name implies, the Rhizobiina live upon the roots of plants. Only apterous subterranean forms have yet been found, and these are commonly of a depressed figure, tinted with pale brown or yellow colors. One form has been found common on the roots of lettuce, in the State of New York; and another species lives on the same parts of the Poa grass, at Carbondale, Illinois.

About one thousand species of the entire family have thus far been brought to the notice of entomologists, and those chiefly from Europe and North America, but by far the greater number still remain unrecorded; and in the United States they have been so much neglected that scarcely two hundred species have yet been made known. They flourish best in the temperate climates, and are to be met with in smaller numbers in many parts of tropical America; but they are by no means absent from the colder regions, and are well represented in the highlands of Scotland, in Sweden, and in the extreme north of British America.

A step in advance leads to the less comprehensive, but singular family PSYLLIDÆ, or Jumping-lice. These are moderately small insects, of firmer texture and stouter limbs than the aphides, but, like them, live solely upon the juices of vegetation, and cause serious injuries to various fruit-trees and bushes.

They somewhat resemble Cicadas in miniature, and their wing-covers rest slanting as in most of the higher Homoptera. The thighs are thick, the hindmost shanks are armed at tip with stout spurs to aid in leaping, and the tarsi two-jointed. They have generally a flat, transverse forehead, with three gem-like ocelli, one situated on each inner angle next the eye, and the third in the suture of the face between the lobes. A very marked feature is seen on the epistoma, which is decidedly cleft, and the lobes

protracted forwards. Each side of these the filiform, ten-jointed antennæ, are situated, and these are thick at base, but armed at tip with two slender bristles, or less commonly with one. The rostrum is short, three-jointed, and placed almost between the fore-coxae, where it fits into a grooved space. Both sexes are always winged in the adult, the wing-covers are ample, and while often transparent, are much thicker than the wings, and furnished with stout curving veins, which enclose a few areoles at tip.

This group is divided into three prominent sub-families, the *Liviina*, the *Aphalarina*, and the *Psyllina*.

The first may be recognized by the long, flat, chisel-shaped head, with narrow eyes, and antennæ with one bristle at tip; the second by the frontal lobes not being detached from the vertex, besides the lengthened cubital petiole of the fore-wings, which is as long or longer than the discoidal part of the subcosta; and the third by the prominent round eyes, detached frontal lobes, and short petiole of the cubitus.

Many exquisitely decorated little insects adorn this group, but the giant and chief of all, though not so pretty, is the neat *Pachypsylla venusta*, which inhabits the *Celtis*, or Hackberry, in the United States. This fine species expands nearly half an inch across the open wing-covers, is of a grayish clay color areated with brown, and has a double oblique row of squarish, dark brown spots along the posterior margin of the wing-covers. By arresting the flow of sap in the petiole of *Celtis*, it produces a round gall which steadily increases in size until it becomes as large as a filbert. This, when dry and hanging upon the stalk in autumn or winter, is so coarse and hard as to resemble the shell of a rough pignut.

Other species of smaller size, such as the *Pachypsylla celtidis-mamma* and allies, make button or cabbage-shaped galls upon the leaves of *Celtis*, and which also become hard and dry by the time of leaf-fall in autumn.

The *Psylla tripunctata* is a wax-colored species with three brown curved streaks, and three darker dots near the posterior margin of the wing-covers. It is peculiar in living upon the leaves of blackberry, which it causes to wrinkle and purse, while it is equally common among the needles of pine trees.

Calophya nigripinnis is a smaller black species with orange thorax, which lives upon the stems and leaves of sumach, and appears fully developed in June and July. The larvæ, resembling rough grains of gunpowder, may be seen spread over the twigs of that bush throughout the winter and spring. After the wing-flaps have developed late in spring, the nymph has the form of a very broad trilobite, and sticks close to the bark like a scale-louse.

A more lengthened and depressed form appears in the genera *Livia* and *Diraphia*, both of which are common upon Calamus and reeds in swampy places of the Atlantic region, although the former is often abundant upon pines and the sugar-maple.

In the family MEMBRACIDÆ we meet with typical Homoptera having three-jointed tarsi, and composing a numerous assemblage of the most grotesque and extraordinary forms of this order. It is, however, chiefly in the prothorax that these curious modifications prevail, and when this is stripped off, as indeed occurs naturally in some species of *Centrotus*, we observe forms which have a body much like the Psyllide, but with broader vertical heads set beneath the thorax, and with two ocelli on the face.

They are of every conceivable form, arched, compressed, depressed, hump-backed, spindle-shaped, pointed at both ends, inflated, hemispherical, conical, and so forth, and are furnished with an equal variety of superficial attachments. The antennæ are short, bristle-shaped, thick at base, and situated under the expanded margin of the clypeus,



TROPICAL HEMIPTERA.

1. *Hypsaucheno bilista*.
2. *Heteronotus reticulatus*.
3. *Membracis leucata*.
4. *Hemiptycha punctata*.
5. *Enchosiphum crenatum*.
6. *Pettiparus quadripunctata*.
7. *Cercopis brevifolia*.
8. *Falgora cuneolaria*.
9. *Tucani speciosa*.
10. *Diactor bilunatus*.

either below or a little in advance of the eyes. The species are all good leapers, with short stout legs armed with a circle of short spines on the tips of the hind-tibiae; but in the genus *Membracis*, and its next relatives, the two forward pairs of tibiae are broadly flattened, and fit very closely against the breast. Their head is of three patterns: the first retains the quadrate, foliaceous form of the ordinary nymphs; the second has the head triangular and wrinkled; and in the third it is short and transverse like a bandeau.

Two figures on the plate, numbers 3 and 5, well illustrate the arched, compressed type common to Brazil and Guiana. The former is jet black, with a yellow front margin and triangular apical spot, and is the *Membracis tectigera*; while the latter is marked with bright red, has a curved horn projecting forwards, and is the *Enchophyllum cruentatum* of authors. But by far the largest of this shape is *Membracis foliata*, which is smoke-brown, spotted with yellow, and measures more than half an inch in length. This genus is very rich in species, and includes some of the most gayly colored and beautifully decorated species of the family.



FIG. 301. — *Membracis foliata*.

Many of these insects affect the axils of twigs, and stems of various bushes or small trees, especially near water-courses, and protect themselves by selecting places which well agree with their pattern of marking.

Here also belong the species which imitate bits of dried brown leaves, belonging to the genus *Stegaspis*, all of which are of the dull brown color, have a ragged appearance, and are often sinuated, as if a piece had been cut out of the back.

Figure 1 of our plate shows the *Hypsanchenia balista*, a dark brown insect, in which the thorax is drawn out backwards into a slender curved arm, as if fitted for a spring to throw missiles. Number 4 of the same gives two attitudes of the large and remarkable two-horned *Hemiptycha marginata*, also a native of Brazil. It belongs to the division with triangular head, to which most of our North American species must be referred.

The *Archasia gibbata* is an apple-green, arched species, similar to the Membracids from South America, but much thicker, and also having a triangular head. It is found in midsummer on our native young oaks and hickories.

A still more compressed form is the conspicuous *Smilia camelus*, Fab., which is sometimes moderately common, in June and July, upon bushes and small oaks. This is one of the gayest colored of our native species, has a rich brown ground color, marked with two converging, oblique yellow bands, and a spot near the tip, with the wing-covers transparent, but clouded with brown at the tip.

To the genus *Telanomus* belong our indigenous hump-back forms, of gray, claret, or greenish colors, which live in June and July upon oaks, hickories, and other forest trees. They generally rest singly on the limbs and branches of the trees with the head directed away from the trunk, but in the younger stages they keep together in small groups. *Telanomus monticola* sometimes swarms upon the branches of the Virginia creeper during the month of June, and helps to destroy this vine by draining its sap, as well as by puncturing the bark to deposit its eggs.



FIG. 302. — *Telanomus monticola*.

Most of the young forms thus far observed are armed above with series of erect, sharp, or forked spines, and the abdomen is terminated by a tube, from which a sweetish substance is ejected, which is very attractive to various kinds of ants.

These insects are connected with the Psyllidæ by the form of the lobes of the head in the young stages, a character which is preserved in the adult *Membracis* and its near allies, as well as by the form of the abdomen, similarity of the wing-covers, and saltatorial legs.

The most aberrant members of this group belong to the sub-family Centrotida, in which the prothorax is often reduced to a mere strip or triangle; in others it is prolonged backwards into a pitchfork or trident, with the scutellum distinctly developed beneath it. Some of the forms of *Heteronotus* have a very hymenopterous appearance, and this is carried still farther in the form, texture, and veining of the wing-covers; others might easily be mistaken from their resemblance to the spinous ants which inhabit the same localities, in Brazil and Mexico.

More than eight hundred species have been described from Africa, temperate and tropical South America, Central America, Mexico, the West Indies, and the United States. Europe is singularly destitute of these insects, of which only two or three forms cross her borders from the near provinces of Africa, while Brazil and the other torrid countries of South America claim more than half the species of the world. Australia and the East Indies possess a few species, but they form no conspicuous portion of the Fauna, and belong chiefly to the Centrotida.

Most of the insects which we have thus far noticed are mute, but we now reach the CICADIDÆ, a group of generally large forms, which have been celebrated in classic and other lands for their wondrous song. They may be recognized by their heavy subconical bodies, wide, blunt head, with prominent eyes on the outer angles, ridged epistoma crossed by coarse oblique ribs, bristle-shaped antennæ, placed in a socket beneath a ledge of the vertex, and three bead-like ocelli arranged in a triangle on the middle of the cranium. The mesothorax is the largest segment, and the metathorax is reduced to a narrow scale. A very conspicuous feature in all of them is a cross-like prominence on the hind end of the former, which adds great firmness to this important part of the chest. The wing-covers are nearly elliptical, longer than the body, parchment-like, but generally transparent, and with a series of eight areoles at the tip; but the hind-wings are more membranous, scarcely exceeding half the length of the former, and with an apical series of six areoles. Their legs are short and stout, not fitted for leaping, the fore-thighs quite thick, armed with two or more thick teeth, also the hind-shanks are bristly, and have a series of sharp spines on each side.



FIG. 503. — *Cicada tibicen*, Lyerman, harvest-fly.

But the most distinctive peculiarity, which has no parallel in any of the other groups, appears in the organs of sound. These consist of two large parchment sacs, ribbed and gathered into numerous plaits, furnished with powerful muscles, and situated in large cavities at the base of the abdomen. When in action the air is driven with great force against the ribbed surfaces, and vibrations are set up which produce

the sound in accordance with the number and form of the fluted spaces and ribs. Numerous modifications prevail in the form, size, thickness, power, and relative position of the parts of these organs, so that there are species which give forth an almost deafening

sharp note, such as the *Pidicina mannifera* of tropical America, and our native Lyerman, *Cicada tibicen*. The latter is a medium sized usually black and green species, which takes two years in its development, and appears during the dog-days in late summer. It varies both in size and colors, is more or less powdered with white beneath, and at base and tip of abdomen above, and is distributed from New York to Rio in Brazil. Its cast pupa skins may often be seen hooked to the bark on the trunks of trees, or to the sides of fences; the fore-legs being very thick and adapted for digging through the soil, and the claws long, acute, and curved.

The largest species inhabiting this country is the *Cicada marginata*. Its colors are black, marked with green, or brownish beneath, where it is also more or less powdered with white. It occurs sparingly all over the eastern United States from Long Island to Florida, and west to Indian Territory, but probably not beyond. The length to the tip of its closed wing-covers exceeds two and a quarter inches.

Besides the above, there are two other principal types of this group in the United States. These are either black or brown, with red or orange markings; or clay-yellow with blackish lines and spots. The former is represented by *Cicada rimosa* of the Northern and Northwestern States. To the second pattern belongs the neat *Tettigia hieroglyphica*, which enlivens the pine woods of New Jersey with its pleasant note, and spreads away southward until checked by the swamps of lower Florida. When fresh it is tinged with green, the costal margin of the fore-wings is of the same color, the adjoining anastomosis is white, and there are two series of brown spots upon the apical series of cells. This country is signalized by having the longest-lived and most remarkably distributed Cicada to be found anywhere on the globe. This is the *C. septendecim*, a medium-sized black species, with bright red eyes, banded with red on the abdomen, and with red and orange veins to the base and costal margin of both pairs of wings.

It lives beneath the earth for about seventeen years, nourishing itself upon the juices of the roots of forest and fruit trees until, being nearly ready to cast off its pupal skin to become winged, it bores a hole to the surface of the soil, and comes forth. At this time it is a clumsy-looking, horn-colored object, about an inch in length, provided with hooked digging shanks upon the fore-legs. They commonly begin to leave their holes about the middle of May, and so continue to do, sometimes until the first of July. Should the weather be persistently rainy when they begin to leave the surface, they construct tubular towers of clay above their holes, into which to retire until drier weather returns.

Several weeks before the time for issuing, they may be found beneath stones, rails, or other objects lying upon the ground, and of which they have taken advantage for protection until the time for changing the skin has arrived. When ready for this change, they crawl to the side of a fence or trunk of a tree, and grasp it tightly with their claws; the skin then splits down the back, the tender creature draws itself forth, remains suspended for a few hours until the superfluous moisture has dried from the integument, the wings have stretched to their full size, and the insect flies off.



FIG. 304. — Pupa of seventeen year Cicada.

It is found only in the United States, and is best known in the region east of the Mississippi River, although it extends west into eastern Kansas. Areas of variable extent are occupied by it, and in each of which it appears at different years. Thus a very large brood extends interruptedly from northern Vermont to Georgia, and thence to Michigan and Illinois, which was first recorded as appearing in 1715. This has been traced at intervals of seventeen years until 1868, and consequently will next appear in 1885. Sixteen distinct broods have thus far been made out, of which four have appeared in New England; the same number in New York, and in Illinois, extending into Missouri; seven in Pennsylvania; three in North Carolina and Virginia; two in Maryland; one in Kansas and Indian Territory; and one in each of the States, South Carolina, Alabama, Tennessee, Kentucky, Arkansas, and Indian Territory; while only one is in Delaware, and that an extension of the one in southern Maryland.

Not only do these insects come forth at intervals of seventeen years, but there are three broods which appear at intervals of thirteen years. One of these belongs to Mississippi and Louisiana: a second to southern Illinois and eastern Missouri, and the third, which is quite extensive, spreads from southern Illinois, through Missouri to Louisiana and Indian Territory, and also into Kentucky, Mississippi, Alabama, and Georgia. In Maryland the brood of 1868 swarmed in countless numbers along the edges of the forests and in places where trees had previously stood. The ground in many places was honeycombed by their numerous holes, and the later specimens were smaller and blacker than the others. A marked difference in their note was observed, which was quite in contrast with that of the year 1851. In the year last mentioned, they swarmed in many of the same localities, as later, but then they seemed to delight in a chorus while sounding the notes resembling *fa-rrho*. In 1868, however, there was rarely a chorus, comparatively few uttered the familiar sounds, many males were perfectly mute, and single individuals would give forth a short, sharp, interrupted shrill noise, or only a few stifled cadences.

Grandest and most conspicuous of all this group is the rich orange-colored *Dundubia imperatoria*. It is a native of Borneo and Nepaul, measures eight inches across the outspread wings, and is the largest Hemipteron yet known. *Thopha saccata* is another very large and rich wine-brown species, in which the drums spread out on each side of the body like great pouches. It is a native of Australia.

The species figured on our plate (fig. 9) is the superb steel-blue, orange-banded *Tacua speciosa*, common in Bengal and other parts of India.

Numerous genera have been separated from the old genus *Cicada*, some of which are finely colored, curiously marked, as if in imitation of butterflies; and others are variously modified in the shape of the thorax and head, while still others have the drums reduced to mere short scales, or have them spread out to cover the entire under-side of the abdomen.

The genera *Platypleura*, *Gaana*, *Tosena* and allies have the wing-covers adorned with opaque bands of brown and other colors, or they are black; while the abdomen is uniformly blood red, or black with a few yellow spots. These belong to China and the adjacent countries, while the first-named genus is represented by species in nearly all the countries and islands between Japan and the Cape of Good Hope.

The new world forms generally have the wings transparent, or with only a few fuscous spots on the outer ends of the wing-covers; but a notable exception occurs in the Brazilian *Carineta formosa*, in which the black head, ornamented with a red line,

is contrasted with two large green spots on the red-bordered thorax, and this too with the golden-yellow wing-covers edged with brown.

About five hundred species are already known, and of these, more than eighty forms inhabit the United States, Mexico, and the West Indies.

This family is connected with the following one by the genera *Polynœura* and *Hemidietya*, in which the veins near the tip of the wing-covers become very numerously branched or areolated. A move in the direction of the Orthopterous genus *Microcentrum*, or katydid, is seen in the wing-covers of the anomalous Australian *Cystosoma*.

The family FULGORIDÆ is distinguished by the presence of the great lantern-flies, and includes also a host of other species of very diverse forms and of many varieties of structure. It contains forms which might have been mistaken for butterflies and moths, and others which closely imitate such genera of Neuroptera, as *Hemerobius*, *Neuronia*, *Setodes*, and others. They may be recognized by the compressed, vertical, often carinated face, and by the bristle-shaped antennæ being set into a button-shaped base on the side of the cheeks beneath the round eyes, and below which latter a small ocellus appears. The wing-covers are generally opaque, and narrower than the wings, but in the subfamilies Dictyopharida, Cixiida, and Delphacida both wings and wing-covers are more frequently transparent.

The family is now divided into thirteen sub-families, Fulgorida, Eurybrachydida, Dictyopharida, Cixiida, Achilida, Tropiduchida, Derbida, Lophopida, Issida, Ricaniida, Acanoniida, Flatida, and Delphacida. Each of these is again subdivided into small assemblages of genera, marked by some exterior feature of resemblance, such as the truncated wing-covers of certain *Flatas*, the triangular form of the same organs in *Ricanias*, the narrow, parallel-sided wing-covers of *Versia*, and so forth. But as it would take a large book to describe the numerous types which belong here, we must select a very few, and refer the reader to the great systematic works of Westwood, Stål, and Amyot for further information.

The splendid *Laternaria phosphorea* or Brazilian Lantern-fly is the largest of the group, although there are other species in Central America, Guiana, Mexico, and in one or two sections of Brazil which are nearly as large as this, but narrower, and somewhat differently marked. This genus was named by Linnaeus from the supposed fact that the species were luminous. No recent traveller, however, who has observed them in their native haunts gives countenance to their luminosity; and they are reported to fly only during sunlight, and not to appear abroad during the night.

In the alleys of the great primeval forests of the Amazonian Basin the great lantern-fly passes its life amid the brilliant orchids and other gorgeous flowers, and occasionally descends to the lower trunks of the trees when pursued by birds and other enemies. This, like many of the butterflies and other broad-winged insects, may sometimes be seen to have a piece taken out of the end of the wings. Such mutilation is occasioned by the activity of the little green or brown lizards, stationed half-concealed on the tips of projecting twigs, so that when the insects fly near, their wings are instantly snapped by these lurking intruders. The *Laternaria phosphorea* measures fully six inches across its outspread wings, and its great, mitre-shaped head is as long, and in front nearly as thick, as its body. Its general color is a greenish yellow, with four long spots on the humps, a series on the side of the head, and the fine veins of the costal border of the fore-wings rose-colored. Numerous spots and lines on the mitre, thorax, abdomen, and legs are either fuscous or black; both pairs

of wings are reticulated with black, and a large iris spot, of an olive color, encircled by dark brown, with two dark pupils invested with bluish and white, occupies the end lobe of the hind-wings. The upper and lower sides of the abdomen, more especially at tip, are coated with white, flocculent matter, and the fore-wings are sprinkled with a white powder.

Next to this is placed the genus *Phricetus*, also composed of large species inhabiting the same regions, one of which, the superb *P. diadema*, has the end of the serrated head-protuberance tipped with a star-shaped diadem, while in front of the eyes is a conspicuous blackish stripe, and above them a prominent black, oblique horn.

To China and the East Indies belong the remarkable Candle-flies, which have also been reputed to give light. They are either greenish or orange yellow, with banded wing-covers, a long, tapering, upcurved head-projection, and with many-veined wings, decorated on the end by a broad, black band. These belong to the recent genus *Fulgora*, the common form being the *F. candelaria* of authors. They are said to be common pets of the Chinese children, who confine them in little wooden cages and offer them for sale in the markets. It is shown in Fig. 8 of our plate.

To the same sub-family are also referred the highly colored and beautifully decorated *Lystras*. The *Lystra lanata* is less showy than some of the others, but it secretes long strings of white fibrous material, which project from the end of the abdomen like strips of silver tape, and which are said to be useful to the insect, as it flies, in saving its life from the birds. The latter, in swooping to grasp the bug, naturally attempt to reach the most visible part of its body, and this, being the bundle of fibres projecting far behind, is seized and bitten off, while the creature passes on unhurt.

Multitudes of species of these insects inhabit the warm regions of Asia, Africa, and America. In the United States three species inhabit the South and Southwest, and one, the *Peocera misella*, extends from Mexico over into the Territory of Arizona. The *Peocera fuliginosa*, the largest of our native species, is in general of a dark brown color, about two-thirds of an inch in length, with a wide head cut almost square off in front, and inhabits Texas, Missouri, and Georgia. They live in bushy places near water, where the soil, being rich and damp supports a rank vegetation.

The Dictyopharida are represented in the United States by *Nersia*, *Scolops*, and *Phylloseclis*. To the first mentioned are referred various pea-green species with clear, narrow wing-covers, and tapering, upcurved heads. They measure about half an inch to the tip of the wing-covers, and these organs are very straight-veined, but closely areolated on the thin end.

The form most common in this country is a neat little insect which lives in summer upon the stalks and leaves of reeds and rushes in the open swamps, both salt and fresh, extending at intervals near the coast from New Jersey to Mexico. When approached, it dodges nimbly behind the stem of the plant, the green color of which it closely matches, and usually remains well concealed; but if hard pressed, it flies off a few feet and lodges, perhaps, on the under side of a leaf, or glides into the axil of some convenient grass. When late summer arrives, and the reeds become blanched by the heat, the remaining individuals of this species also lose their color, and acquire that of the dried stems on which they live.

Scolops sulcipes is another singular and widely distributed member of this group. It lives on grass and various plants growing on damp spots near the edges of woods in Maryland, but farther west it frequents low spots in the prairies. It is an oval, dull straw-colored insect, about one-third of an inch in total length, with a long,

slender, up-curved stylet projecting from the front of the head. Its eyes are brown; there is a blackish stripe each side of the face, a few spots of the same color appear on the front of the thorax, and the veins of the wing-covers are often margined and spotted with brown. The legs are long, the hind-shanks are armed exteriorly with a row of acute spines, and at tip with a crown of stout teeth, which greatly assist the creature in starting to leap. It occurs pretty generally throughout the United States, being found in various places west of the Rocky Mountains in Washington Territory, Oregon, and Nevada, and continues south into Arizona, New Mexico, and Texas. On the eastern side of the continent it is found from Canada to southern Florida.



A related but still more singular genus is *Phylloscelis*. It was founded by Prof. Germar upon two small, blunt-headed, oval species, having the fore-thighs expanded into flat plates; based, however, upon only the form with incomplete wing-covers and arrested development. As usually seen, they have a thick, crustaceous integument, with the wing-covers correspondingly thick, lacking all indications of a membranous tip; but in the completed form the membrane is distinct. They have a narrow, vertical face, with very large, round eyes overlapping the prothorax, and long hind-shanks, built for leaping.

One species, *P. atra*, is either all over black, polished, sometimes marked with orange; or it is orange, marked with black on the wing-covers. Its fore-tibiae have two white spots, the other tibiae are more or less striped with white, and it has but a few remote veins in the wing-covers. The other species, *P. pallidescens*, is of a dull gray color, more or less speckled with white and black; the face is ribbed, and the raised lines flecked in series; while the fore-thighs are black, dotted and thrice spotted with white, and the tibiae, except the hinder pair, crossed by a pale streak or spot. They are both of small size, measuring only one-fifth of an inch in length; and inhabit the United States from Massachusetts to Florida, and extend west to the great plains and south to the borders of Mexico.

Both forms live in weedy places, amidst herbage and vines along the edges of woods, in low grounds. The latter species approaches nearer to *Scolops* in the numerous veins and cross-veins of the wing-covers.

This group is represented in Europe by only a few forms allied to *Nersia*, such as the pale green *Dictyophlura europæa* and *D. pannonica*, which inhabit chiefly the more southern countries. The foregoing remarks give but a very inadequate idea of this large sub-family, which is marked by many strange genera and species in all the tropical and sub-tropical regions.

The sub-family Tropiduchida is composed of numerous genera and species, belonging chiefly to the sub-tropical or tropical regions of Asia, Africa, and America. It is represented in Florida, Texas, and the West Indies by clear winged forms, generally of a green, or straw-yellow color, closely resembling *Nersia* in nearly all but the shape of the head. The wing-covers are long and narrow, gradually widening at tip, and bluntly rounded. The head is oblong, pentangular, with the edges raised, and generally a keeled line along the middle which ends behind in a notch; and the hind-margin of the prothorax is deeply, acutely emarginated and keeled, while the mesothorax has three slender keels.

In *Tangia sponsea*, a pale green insect, with milky, transparent wing-covers, the

head is nearly as long as the mesothorax, the eyes are sometimes reddish, and there is a strong transverse vein behind the middle, separating the membrane of the wing-covers. Like *Nersia*, it is bright green early in the season, but later becomes paler, or even bleached straw-yellow. It inhabits Cuba, San Domingo, and southern Florida; measures half an inch to the tip of the wing-covers, and lives upon reedy plants near water.

Monopsis tabida is a similar, but smaller form, which inhabits the same regions, and nearly the same kind of places, as the preceding. It is also pale green, and has a very short, more quadrangular head. Several allied forms inhabit Mexico and Central America, and there are others in Brazil which are larger, and that have very long and narrow heads.

We now reach the sub-family Derbida, a group of moderate extent; but one which comprehends some of the most beautiful and delicate forms of the entire order. Here the head is generally produced forwards; sometimes extremely compressed, and then with the sides prominently keeled. Such a contracted cranium offers but very limited space for the accommodation of the brain; and the reduced size of the principal ganglia in these delicate creatures may account for the general feebleness of their motions. The wing-covers are long and slender, a little widened at tip, furnished with few apical areoles, and give the insect an appearance much like that of the slender-winged pyralid moths, or the neuropterous *Setodes*. They may also be recognized by the form of the antennæ, which in some are divided into three stout and long branches, while in others the base is surmounted by a long, thick shaft. Their legs are simple, and with extremely short spines on the tip of the hind-shanks.

Otiocerus coquebertii, is a gay, lemon-yellow or cream-colored species, with a broad stripe on the side of the face and wavy red forked lines on the wing-covers; the head,



FIG. 306. — *Otiocerus coquebertii*.

as seen from the side, is of the form of a ploughshare, with the little brown eyes standing out like beads. The antennæ have three bent appendages resembling strips of tape. It measures about one-third of an inch to the tip of wing-covers, lives upon the leaves of grape-vines, oaks, and hickory, in July, August, and September, and is distributed over a wide area, being found in the vicinity of

the White Mountains, in New Hampshire, also in northern New York and Illinois, and extends from thence to central Texas, and east to Georgia. A rose-colored species, with the markings of the head, thorax, and veins of the wing-covers carmine, is the *O. degeertii*. It is of about the same size as the preceding, and inhabits similar places at nearly the same time of the year.

Anotia is a still more gauze-winged, smaller form, of the utmost delicacy. It differs from the foregoing genus in having the second joint of the antennæ long and blade-like, not branched, but notched at the tip, and into this the bristle is inserted. The *A. westroodii* is pale yellow or whitish, has the wing-covers irregularly clouded and spotted with light brown, and the veins of the apical part of the costal area bright red. It lives on the spice bush and willows, during August and September, in the Middle States; and upon grass and willows in northern New York.

Tropical and sub-tropical America is rich in genera and species of this group; many of which resemble moths and Phryganidae, and some of the brown species imitate

Diptera of the genus *Pyrgota*. They are all feeble insects, which leap with only moderate facility, and which depend chiefly upon their large wings to escape from enemies.

A series of this group stands apart from the other genera in being destitute of the appendages commonly attached to the base of the antennae. One of these is the American genus *Lamenia*, which is represented in the United States by three species of slate-blue color, more or less powdered with white, and closely resembles the neuropterous genus *Aleuconia*. The best known of these is distributed from Maine to Georgia, and from Illinois to Texas. It is the *L. vulgaris*, a broader-winged insect than either of the forms noticed above, in which the forehead is not produced, but vertical, gently curved downwards, and strongly keeled on the side margins. Its eyes are large, and the knob-like antennae placed immediately beneath them are guarded by a scoop-shaped appendage of the cheeks. Specimens usually occur singly or in pairs upon a great variety of plants and trees. They have been taken from the skunk-cabbage, alder, and wild grape in June and July, and from the oak and hickory in late summer and until near the end of October. When rubbed, or wet by rain, they appear black, blue black, or purplish-black; but when freshly changed from the nymph, the colors are paler, bluish tinged with white. This species measures about one-sixth of an inch to the tip of the wing-covers; but there are other species in Arizona and the Atlantic region of much larger size, and tinted with brighter colors.

The genus *Mysidia* belongs here, which has species nearly half an inch in length, and which closely resemble various kinds of pale-colored moths. It belongs to the tropics of South America.

Another sub-family, the Lophopida, belongs to the Orient and Africa. Thus far none of its representatives have been discovered on the western continent. A single form from Caffraria, *Elasmosectis cunicoides*, will serve to distinguish this small but singular group. In form it is reversed lyrate, with the front of the head narrow, scooped out, and the carinate sides raised like ears. Its wing-covers are rounded at base, diagonally narrowing towards the end, cut obliquely inwards at tip, and having the wide and very conspicuous costal areole crossed by numerous veins. Both its fore-thighs and shanks are expanded into wide, flat plates. Its ground color is a clear light brown, with a window-like whitish spot on the middle of the wing-covers, and with various other white spots on the outer margin. It measures about one-third of an inch to the tip of the wing-covers.

In the next sub-family, the Issida, we meet with a very large assemblage of close-set, robust forms, widely distributed in both temperate and tropical regions, and rich in genera and species. Already more than fifty genera, including over two hundred species, have been reported from Europe, Africa, the United States, Mexico, and South America. Two genera, *Hysteropterum* and *Issus*, are unusually well provided with species in the first-mentioned country; but North America, the West Indies, and Brazil have a preponderance of the abnormal and singular forms.

This sub-family is characterized by a wide, generally blunt head, scarcely narrower than the thorax, feebly or not at all carinated on the sides. The base of the prothorax is cut straight off, or only very slightly concave, and the exposed dorsum of the mesothorax is short. The wing-covers are thick, broad, curving over the body, sometimes nearly enclosing it, and they often have numerous, close-set areoles from near the base to the tip. Their shanks are stout and prismatic, the hind pair often armed with coarse spines on the outer edge, and the tip is crowned with groups of short teeth.

They are generally short, plump insects, occasionally with the tip of the wing-covers contracted and produced, and display great facility in leaping. Many of them have a rough, bark-like exterior, closely matching the limbs and branches upon which they rest, and which serves to conceal them from the eyes of pursuers.

Bruchomorpha and *Naso* are notable exceptions to the general form in this group, in having the head drawn out into a snout like some of the curculionid beetles. These are either gray, bronze-colored, or black insects, often with a yellow stripe along the head and thorax. *B. dorsata* has the head conical, but compressed to an axe-like edge at tip. The head in *Naso* is much larger, also obliquely deflexed and ending in a bulb-like tip. Many species of these genera have been discovered in the United States. They are all small forms, rarely much more than a line in length, and all of which have thus far been described from the arrested imago with short wing-covers. They are found from Canada to Florida, and from Dakota to southern Texas, being met with in large numbers, chiefly in low meadows and on prairies, where they enjoy the juices of the tender grassy plants. The genus *Naso* is sometimes common in similar places in Florida, Texas, and Kansas. Hibernation takes place in *Bruchomorpha*, and such females as survive until the return of warm weather lay their eggs, and the young are developed through the summer, so that by the latter part of this season the fully adult individuals appear in the greatest numbers.

But the types which better represent this group are to be found in such genera as *Issus*, *Tylna*, *Hysteropterum*, and their near allies. In the former we observe blunt-faced, stout insects, having the head very short, much narrower than the thorax, with the wing-covers a little rounded, inflated before the middle, and slightly narrowed towards the tip. The species are usually dull yellow, gray, or brown; and live upon the branches of low trees and bushes. *Tylna* is represented in the United States by several medium-sized species. The one best known is the *T. conspersa*. It is a moderately broad form, of a dull chestnut-brown color, with a few blackish dots on the middle of the wing-covers, having the veins wide apart, and very few apical areoles. When living the under-side of the body is pale green. Specimens occur singly or in pairs, during September and October, on different species of hickory, selecting in preference the younger and more tender trees. Thus far it is known from only a few of the States bordering on the Atlantic Ocean. Other species have been found in Arizona, Tennessee, and Pennsylvania; and the genus is represented in the Mauritius by at least two species.

Hysteropterum is an allied genus which has the head still more blunt and wide than in the preceding. It belongs chiefly to Europe, where it is represented by at least twenty-five species, mostly of pale colors and small size. *Mycterodes* differs from the foregoing chiefly in having the head conically prominent, and the vertex scooped out and carinated on the sides. *M. nasutus* is a pale clay-yellow insect, with olive-tinged wing-covers, and dorsal surface of abdomen black. It measures about one-fourth of an inch in length, and inhabits Austria and the southern parts of Europe.

Issus has the head blunt, but not so wide as in either *Tylna* or *Hysteropterum*, but the vertex is very distinctly separated from the front by the transverse carina, and above which the head is made tabulate by the lateral and posterior carinate margins; the face has also a very distinct, incomplete carina down the middle, and the veins of the wing-covers are closely reticulate behind the middle. *Issus coleoptratus* is perhaps the most widely distributed species in Europe, where also eleven other species

inhabit the wooded parts of the country. Several species also inhabit the United States; but most of these are small and inconspicuous forms.

A strictly American type, of agreeable green color and great activity, confronts us in this group, and is one which has a wide distribution in North America. It belongs to the genus *Amphisepta*, of which *A. bicittata* is the best known species. When living the color is a vivid grass green, with a vertical, sharp-edged, more or less brown face; the prothorax is flat and has two darker brown stripes, which unite behind and pass along the upper margin of the wing-covers. Strong veins commence to fork near the base of the latter, and are connected by clearly-defined branching cross-veins, which increase in number towards the tip. These wing-covers are also very broad, are held nearly vertical, and are almost cut square off at tip. The hind-shanks are long, slender, and armed with a pair of short teeth on each side.

Individuals of this species are occasionally met with in Florida which have the head, thorax, and base of the wing-covers changed to a decidedly rosy tint; and still more rarely specimens occur which entirely lack the darker markings of the head, thorax, and wing-covers. This species is distributed from Canada to Florida, and from Minnesota to Matamoras, Mexico. In late summer it may be often seen resting upon a stalk of grass or branch of a blackberry bush, keeping a sharp lookout, so that when suddenly approached it gives a rapid leap which carries it several feet away into a place of excellent concealment, in the midst of tangled grass or inextricable twigs and branches.

Closely allied to the foregoing group is a very small sub-family, Eurybrachidida, the species of which were formerly included in the same division as *Issus*. Only one genus, *Eurybrachis*, is at present here included. The species are generally about one-half of an inch in length, of very robust proportions, with exceedingly blunt and wide face, short vertex, with expanded wing-covers curved on the sides, and veins much branched at tip. They also have the fore and middle thighs and shanks expanded into plates, and inhabit the lowlands of the East Indies, Australia, and the Philippine Islands. They are generally of an orange ground-color, marked with green reticulated bands on the wing-covers, and the legs are red.

The great and well-marked sub-family, Ricaniida, has no known representative in the United States. The species are all tropical or sub-tropical, inhabit the moist parts of the hot regions, and are more numerous in the East Indies and adjacent islands than elsewhere. At least one large and beautiful form has been found in southern Japan; and a rich brown species occurs in the Philippine Islands. They may be recognized by the head being as wide as the thorax, with a broad, flat face, very short vertex separated from the front by a transverse keel, and the mesothorax with three slightly raised longitudinal lines. The wing-covers are held nearly vertical, are very large and triangular, at tip almost as wide as long, with very numerous longitudinal veins accompanied by wrinkles. A conspicuous feature at their base is the large, scale-like tegular pieces, which cap the hinge there. The first tarsal joint of the hind-feet is also very short.

Ricania fuscata is a very large species, measuring fully two inches across the expanded wing-covers. It is generally of a smoke-brown or blackish color, although some varieties are more or less marked with yellow beneath and on the sides of the abdomen, and are also banded with pale ochreous across the forehead. It inhabits Borneo, Java, and the East Indies.

Several smaller species occur in Luzon, Burmah, Malacca, and the adjacent coun-

tries, which are dark-brown, spotted or banded with white or hyaline, giving them very much the appearance of small hesperian butterflies.

The most exquisitely beautiful of all this group is the *Pochazia splendida* from New Guinea and the islands of the Malay archipelago. It measures a little more than three-quarters of an inch across the spread wing-covers, and has a highly glossy surface which serves to render more brilliant its somewhat iridescent colors. The thorax and head are pitch-black, both marked beneath with orange. On the sides of the abdomen a paler yellow prevails, and the legs are still paler yellow. But the wing-covers are brilliant orange, changing to glassy behind the middle; they are bordered all around with a rich brown which reflects a steel-blue tinge, and catches a greenish tint where it approaches the orange ground; and on the disk is a double purplish-brown spot with a pale bluish or white round pupil. Its wings are whitish-hyaline, also bordered with brown, and with a pale brown cloud on the middle. This glowing beauty, when placed in the sunlight, vies with the elegant satin of the most delicate *Morphos*, and in pattern of marking recalls the little pearly butterflies of the Erycinid genus *Mesosemia*.

Brazil claims but very few of these attractive insects; but the most conspicuous one which belongs to her domain is the *Nogodina*. In this genus the close-set veins are aggregated near the tip of the wing-covers, and the disk is full of small meshes which become more numerous in the direction of the apex. *N. reticulata* is a pale ochre-brown species, measuring a full inch across the wing-covers; with clear wings crossed by three broken dark-brown bands, and with the apical and most of the costal margin also marked with brown. The dark, rich brown of the wing-covers strongly contrasts with the glassy surface upon which it is placed, and gives the insect very much the appearance of one of the tortricid moths. It inhabits the vine-clad clearings in the great forest region of Brazil, and dwells in lazy ease where multitudes of its more remote relatives find equal gratification in sitting all day long imbibing the juices of some convenient twig or bud.

A step forward leads to the great and extraordinarily varied sub-family, Flatida. Here the exuberance of form and variety of pattern prevails almost beyond a parallel in any other of the groups. Here the head is much narrower than the thorax, with the prothorax produced forwards and narrowed in that direction. That part of the mesothorax which is not covered by the wings is relatively larger than in the Issida, and not always triangular. When the head is blunt, the vertex is short, but in some small assemblages of species the latter is produced, and conical in outline. The wing-covers are large, obtriangular, or lyrate, with the costal margin broad, dilated at base, and crossed by numerous partly-forked veins. At base and on the clavus the surface is usually more or less granulated; the latter is well separated from the corium by the suture, and has two very distinct curved veins running throughout its length. The genus *Flata*, from which the group is named, now consists of large, semicircular winged forms, one of which, the *F. limbata*, is of a bright grass-green color, having the wing-covers bordered in front with bright red, while the wings are milk-white. It measures more than an inch and three-fourths across the spread wings, and the wing-covers are very distinctly marked by veins which branch very numerous and slenderly toward the tip. It inhabits tropical India, and is reported to occur also in southern China.

A common North American genus of this group is the *Ormenis*. It is, however, not confined to this continent, but is represented by other species in various parts of Africa. Two well-known species are common in the United States; the one, *O. septentrionalis*, is a pale green insect, powdered with white, tinted on the front, on the

under-side of the body, and on the costal margin of the wing-covers with yellow; the wings are milk-white. The wing-covers are a little wider at tip and cut square off. It varies considerably in length; measuring from one-third to nearly one-half an inch from the front to the end of the wing-covers.

In the latitude of Maryland it affects the wild grape-vines, drawing nourishment from the tender shoots and midribs of the leaves during its young stages. It may also be seen occasionally upon the black alder and other bushes near brooks and marshes; but in the adult stage it lives upon a variety of small trees and bushes, without seeming to take food from any of them. Its feeble, fluttering flight strikingly recalls that of the small, white Arctian moths.

The other species, *O. pruinosa*, forms quite a contrast to the preceding, although living in similar places, and having much the same habits. It is a coarser insect, of a slate, dark gray, or blackish color, which is made to appear bluish by the pruinose powder that covers most of the surface. When fresh, the head, face, under-side of the body and legs are yellow, the costal margin is white, and the wings are smoke-brown. When rubbed, the wing-covers are seen to be blackish, becoming translucent towards the tip, and having a pale spot at the pterostigmal areole, and a larger spot next the basal angle of the corium, the latter marked with three or four roundish, black spots; the suture bounding the clavus is also of a pale yellow or whitish color. It is a little smaller than the preceding species, and has the basal angles of the wing-covers more distinctly prominent.

Mr. Riley informs us that the female cuts a continuous slit with its ovipositor in the skin of sassafras twigs, the edges of which are thereby turned up and bring to view a regular series of long, oval, yellow eggs, with the end of one tightly pressed upon the end of the next, and so on to the extremity of the row. "About the middle of May these eggs produce little hoppers, which leave a thin pellicle attached to each shell at the point of egress. As soon as they are fairly engaged in pumping the sap of the tree on which they hatch, these insects copiously secrete a white, mealy substance, which completely covers them." After shedding the skin three times, they reach the adult stage. This is generally reached in late summer or early autumn, although numbers of the nymphs may often be seen as late as the middle of October in Maryland, sitting upon the leaves of black alder, paw-paw, and other bushes, or creepers, in damp situations. It has a wide distribution, extending from Mexico and the West Indies northeast to the Mississippi Valley, and from thence through all the States to eastern Massachusetts.

Near these is placed the genus *Flatoides*, which includes a few of the most remarkable insects known. Some of these are residents of Madagascar; two or more species inhabit tropical South America, another is found in Mexico, and still another in the West Indies.

F. tortrix well represents the genus as it appears in Cuba and San Domingo. It carries the wing-covers nearly horizontal, and in this attitude the insect has the outline of a wide feather-fan. The costal area is very wide, produced into prominent lobes at base, and is crossed by a series of close-set veins which fork on the outer ends. The thorax narrows towards the head, the prothorax forming a lunate cap, fitting between the eyes, and the head, correspondingly narrow, is turned up at tip. On the somewhat flat sides, the hemispherical eyes project very prominently. The general color of the insect is a pale gray, closely powdered with white; the under-side, the abdomen, and legs being pale brownish or yellow. On the wing-covers, which have a

wavy surface, an oblique band passes behind the shoulders, a narrower one, intersected by another running outwards towards the tip, is placed beyond the middle, and a streak of the same color runs lengthwise in front of the middle. A few short lines of pale brown are sometimes also present on the veins which enclose the narrow areoles of the tip. The veins of the wings are also distinctly brown. It is very variable in the pattern of marking, and also in color. Occasionally a specimen occurs with a deficiency of the white powdery coating, and is then usually of a pale brown, or ochre-yellow color, distinctly marked with broader brown stripes. Full-sized specimens measure nearly an inch and a quarter across the outspread wing-covers. The Madagascar species are larger, but of the same form and general appearance as the preceding. The former are found somewhat common upon the young guava and other trees of the plantations in Cuba and San Domingo.

Immediately next to these comes the genus *Dascaidia*, which is also a West Indian form, but common to all the Antilles, Mexico, Georgia, and Florida. *D. punctata* is nearly of the same form as the foregoing species, but is not quite so broad, lacks the wavy surface of the wing-covers, and has a shorter head. Its color is a sober gray, sometimes tinged with olive, with dark brown spots on the disk, the principal veins fuscous, some freckles on the base of the thin margin, and a series of dark, minute points directly next the apical edge. The body, legs, face, and rostrum are yellow or ochreous, while the front margin of the mesothorax and apex of the head are dark brown. It usually measures nine-tenths of an inch across the expanded wing-covers, but the males are somewhat smaller. Specimens from Georgia are often of much less size than those from Florida and the West Indies. In San Domingo and Cuba it attains the largest size, and often abounds upon the branches of young logwood trees during April and May. Other species are found in Mexico, Central America, and South America; but none have thus far been reported from the eastern continent.

Another form, tapering towards the end of the wing-covers, but closely related to the preceding, is *Cyarta*. The species of this genus are usually pale brown or yellow, inscribed and clouded with dark brown. Their face is about as broad as long, slanting upwards, carinated each side, and separated from the epistoma by a deep transverse suture. The vertex is short, has a thick margin in front, raised sides, and a short carina on the middle. Behind this the prothorax has a recurved front margin, with a groove in the middle and a raised process each side of it, and the mesothorax has a moderately distinct carina each side of its depressed disk. A most striking feature of these insects appears in the curved and inflated base of the wing-covers, from which the corium is continued back long, narrow, and almost parallel-sided. Here also the clavus is broadly dilated into an are, and set with three lines of distinct tubercles. One species is very common in Florida; a larger one abounds upon guava bushes and small acacia-trees in Cuba and San Domingo, and others inhabit Mexico, Central America, and Brazil.

Only one more form can now be mentioned; although this group contains very many other curious and interesting representatives. In this genus, *Poeciloptera*, our attention is directed to a set of large and conspicuous forms, gay and attractive in color or markings, and remarkable for the phalaenid pattern of their ample wing-covers. Perhaps the best-known of these is the *P. phalaenoides*.

It is pale yellow, the wings, and ends of the wing-covers white, and the latter closely marked with series of black dots at base, especially near the inner and outer margins.



FIG. 307. — *Poeciloptera truncaticornis*.

It varies greatly in size, the small specimens being only a little more than an inch in width across the spread wing-covers, while the large ones measure fully an inch and a half at the same place. A variety has the wing-covers almost covered by the black dots, and these sometimes run together in the form of large spots. The common type closely resembles moths of the group of *aretians*, and this one especially imitates the colors, markings, and somewhat the form of *Spilosoma canea*. It inhabits the tropics of Brazil, being common in various places near Para, Bahia, and Rio de Janeiro. There, in the midst of the splendors of vegetation, it dwells upon the branches of various creeping plants, and at times conceals itself from the attempts of pursuing birds by hiding in the bunches of orchid flowers which hang ever ready for its protection.

The sub-family *Achilida* is composed of neat, medium-sized or small insects, somewhat parallel-sided, which have the wing-covers opaque and often mottled, or marked with branching figures, or banded with bright colors. The head is narrow, and either blunt or a little produced, the body rather depressed, and the fore-thighs, trochanters, and shanks are of about equal length, while the hind-shanks are either unarmed, or furnished with one or three spines on the outer margin. On the tip of the latter a pair of exceptionally thick and large denticulated spurs occupies the sides of the notch into which the tarsi are set.

The beautiful *Phetoderes collaris* belongs here, and forms an agreeable offset to the more sober-colored species in the midst of which it is placed.

It is a coal-black insect, with a bright orange band upon the back part of the mesothorax which passes forward to and crosses the face. The head is more than normally wide, but is not as wide as the prothorax, unless the very large, prominent eyes are counted in the measurement. Three carinate, longitudinal lines occupy the disc of the mesothorax, and the prothorax is a mere sinuated collar. A short yellow stripe is often present upon the costal areole, and the disc is sometimes marked with short, remote orange streaks. It is about one-fourth of an inch in length to the tip of wing-covers; and it lives on low bushes near watercourses in the province of Para, as well as in other parts of the Amazonian basin.

North America shares with Europe the interesting genus *Helicoptera*. In the former country, however, it is not confined to the warmer parts of the continent, but lives with equal freedom in the ancient forest region of Lake Athabasca, in the pine barrens of Georgia, or upon the almost sterile plateau of San Diego, California. Wherever a solitary pine-tree can find place to thrust its roots into the hard soil, there the *Helicoptera* settles and brings up its numerous progeny. These insects have more of the form of a feather fan than the preceding, having the narrow, produced, and generally triangular head in the place of the handle.

The species first discovered in this country was *Helicoptera opaca*. This species is of a soot-black color above, closely dotted with pale atoms, has a pale yellow spot on the costal border near the tip of the wing-covers, while a broad, orange band crosses the face and extends upon the sides of the chest. A small yellow spot also covers the tip of the scutellum. The head forms a blunt triangle as seen from above, has the side edges turned up, and a grooved middle line bounded each side by keeled edges. It measures from apex of head to tip of the wing-covers rather more than one-third of an inch. At first only a few specimens, col-



FIG. 308. — *Helicoptera*.

lected in New York, near Lake Erie, and in Indiana, were known to science, but more recently others have been captured in Pennsylvania, Maryland, New Jersey, and Georgia, but not in large numbers. It is reported to have been found in the first-named State on pine bushes. An allied species is sometimes seen in Maryland, Virginia, and New Jersey, upon the limbs of small pine-trees which grow on the outskirts of the 'pine barrens.' Other species are common in strips of thinly growing woods of the same kind in Nevada, Montana, and Washington Territory. The name of the group has been taken from the genus *Achilus*, founded upon an exquisitely beautiful coral red insect inhabiting Australia.

In the sub-family Cixiida we meet with forms which are widely distributed, and well-known in Europe and North America. On the two continents there are parallel species of several of the genera, which are either very closely related or merely geographical varieties of the original species. Thus, *Cixius nervosus* and *C. stigmatus*, are to be separated only with difficulty, and so with other species of this, as well as of *Oliarus*, and other related genera. Our best known North American form is *Cixius stigmatus*. It has somewhat of a clothes-moth form, with the thorax and base of the wing-covers chestnut brown, the latter usually crossed by two imperfect brownish bands, and closely dotted with the same color along the stout veins. The vertical face is coffin-shaped, pale brown above, yellow below, and with the middle carinate line and raised lateral margins also brown. It measures one-third of an inch to tip of the wing-covers, and has some varieties in which the wing-covers are more or less permeated with a claret-brown color. The variety described above is often very common upon small pine-trees in late summer, where also the young forms appear in the spring and early part of the summer. It is distributed from Canada to Texas, and from New England to the highlands of Georgia. Several other species inhabit North America, one of which is found as far north in British America as its food-tree exists. Other genera of this group, such as *Myndus*, with a broader forehead than in *Cixius*; *Ecleus* with a narrow, parallel-sided vertex; *Oliarus* with an emarginate base to the head, and five raised lines on the thorax, inhabit the United States, and are represented by numerous species.

The singular and rare little *Bothriocera signoretii* is the North American representative of a genus which has many larger and more showy species in South America. It is a smoke-brown insect, with a square vertex raised each side into quadrangular keeled lobes, with six whitish spots of various sizes on each wing-cover. It lives on alder and other bushes in wet spots, or near running water. At present it is known from Maryland, Georgia, Texas, and Mexico.

A closely related sub-family, the Delphacida, generally have narrower wing-covers than the foregoing, and, like the better-known forms of that sub-family, belong especially to the temperate region of Europe and America. They are often small, or even minute, and sometimes swarm upon low plants in damp situations. Strawberry beds, and rich soils in low meadows which support a rank vegetation, are their favorite places of abode, where they may be seen hopping about with the nimbleness of fleas, from early spring until late in autumn. They are mostly narrow-bodied insects, occasionally compressed, but more rarely short and plump. Their wing-covers, when developed, are commonly long and narrow, straight-veined, with a few areoles at tip. The head is narrow, with the two basal joints of the antennæ very wide, either one or the other very long, and the terminal bristle extremely slender. But the most distinctive character is seen at the apex of the posterior shanks, where the inner corner is

armed with a long, acute, movable spur. They are either plain colored, or decorated in various ways with bands, stripes, and spots of brown, yellow, or other strongly contrasting colors. There are usually two forms in each species; the one with short, undeveloped wing-covers, and less specialized body, the other with all the organs fully complete. Both forms, however, are really adult insects, and alike contribute to the continuation of their species. The group as known in this country may be distinguished by a reference to the large, although but little ornamented, quite common *Liburnia vittatifrons*. When fresh it is green like the grasses upon which it lives. It has a tumid forehead, tabulated face, an epistoma banded with black, lines of the same color on the coxæ and legs, with marks or bands of fuscous on the breast and undersides of abdomen. It varies very much in the amount and position of the black marking, and some specimens are nearly uniform green throughout. In length it varies from two lines to fully one-third of an inch. It lives on the stalks of rushes and reeds in the salt marshes of New Jersey and Maryland, and is also found on grasses in alkaline damp spots in Dakota and Montana. When weather-beaten or old, it changes its color to match the dull straw tint of the sun-dried vegetation on which it dwells in its native swamps. Some other genera, such as *Delphax*, *Stenocranus*, and *Asiraca* are common to this country and Europe. The smaller forms are usually black, brown, or yellow, and banded with white or other contrasting color.

In the great family CERCOPIDÆ, we observe forms quite unlike any that have been previously noticed, and some which mark an important advance in the direction of the Heteroptera by the large size of the prothorax and increased freedom of the fore legs. This extensive piece is no longer a mere cap or scale as in most of the Fulgoridæ, nor yet a lid, case, or bubble-like expansion as in the Membracidæ, but is an important regional portion, exercising various important functions. Here the front of the head is generally prominent, in the form of a ridge, which is crossed each side by a series of more or less distinct grooves. There are two conspicuous ocelli placed on the vertex, far back. The prothorax is six-sided or trapezoidal, cut square off in front, and the triangular scutellum is of medium size. There is generally a marked difference between the apical area and the other parts of the wing-covers, the former being membranous and sometimes transparent, while the remainder is thick and leathery, or crustaceous. The legs are generally stout, the hind pair being longer than the others, having the shanks armed exteriorly with one or two stout teeth, and the tip crowned with short, stout spines.

At the very verge of the group we find the anomalous sub-family Eurymelida. This is composed of conical forms, with the broad, blunt head as the base of the cone; this part also lacks the frontal ridge common to the others, or has only a vestige of it. The triangular scutellum, as long or longer than the prothorax, occupies all the uncovered part of the thorax. Thick, slanting wing-covers, very slightly thinner at tip, extend back beyond the end of the abdomen, and have a curved costal margin, succeeded by a broad area with forking, oblique veins near the tip. The cheeks are very wide in most of these, and almost conceal the fore-coxæ. As seen from above, the abdomen is very regularly conical, highly polished, and acute at tip. The legs are stout, rather short, prismatic, armed with two teeth near the end of the hind shanks, with very short bristles on the femora and shanks, and with the first and third tarsal joints long, and of nearly equal length.

Most of the species are steel blue, bronze, or black above, with a red or yellow abdomen, and white, red, or yellow spots, stripes or bands upon the head, thorax, and

wing-covers. *Eurymela fenestrata* is black, somewhat bronzed, with the base of the wing-covers orange, and two white spots upon each of them. The abdomen and under-side of the body are orange, the latter tipped with black, while the bases of the femora are bright orange. It measures half an inch to the tip of closed wing-covers. This species and most of its congeners inhabit Australia; but a few others are natives of Van Diemen's Land. About twenty species have thus far been discovered, all of which have been brought from one or both of the countries mentioned.

In the next sub-family, the Cercopida, we find moderately large forms, which take the highest rank within the limits of the family. The face in these always forms a distinct vertical ridge; they are generally oval or ovate in form, and often have the upper surface smooth and highly polished, as is seen in many beetles. An extraordinary variety of ornamentation prevails in the colors and pattern of marking upon the upper surface, giving them a very gay and attractive appearance.

Possibly the largest and most conspicuous species of this group is the *Tomaspis furcata*. Its body is blue-black, with the face, prothorax, base and tip of the wing-covers, and underside of the fore-femora, coral red. The remainder of the wing-covers is orange, ornamented with a long, forked, black streak near the base, and two marginal black spots near the tip, connected by a band which follows the curve of the apical margin. The deep black scutellum is indented, and forms a strong contrast with the bright red of the adjoining surface. Large specimens measure nearly two inches from tip to tip of the expanded wing-covers; but small ones scarcely exceed an inch and a half in the same direction. This beautiful species lives in the tropics of Brazil, and is very widely distributed, being found from the Amazon basin all the way to Rio, and over a large part of that empire from east to west.

The showy *Cercopis bicittata*, a black, shining species, with metallic green wing-covers crossed by two yellow bands, is figured on the left side of our plate. These insects abound in the tropics of both hemispheres, where multitudes of the largest and most showy appear in numerous species.

Tomaspis is a closely related genus represented in the United States by *T. bicincta*. It belongs to a small assemblage of banded species which occur also in Mexico, the West Indies, and Central America, but which have the largest and most showy representative in the *T. rubra* of Brazil. Our species is a dark brown insect, having the under-side of the body, the head, front and side margins of the prothorax, the legs, hind margin of scutellum, and base of wing-covers red, the latter with two narrow bands of orange, one before the middle, the other behind it; besides these there is a band of the same color across the middle of the prothorax. Usually there are two black spots upon the head, and four rows of others on the venter. It is one-third of an inch in length, and measures three-fourths of an inch across the spread wing-covers. This insect is a most active leaper, appearing adult in the Middle States from the latter part of June until the end of warm weather. Specimens are usually taken singly by beating blackberry bushes, black alders, and some other low shrubs in low grounds. A variety (described by Dr. Fitch as *Monephora ignipecta*) lacks the yellow and more or less of the red marking of the upper surface. Corresponding varieties also belong to other similar species inhabiting Mexico, to one or two others in Central America, and to still another species in Cuba. The posterior band of the wing-covers sometimes becomes wider, or is interrupted, or in some Texan specimens is changed to red.

Europe possesses six nominal species of a division of the old genus *Cercopis* called *Tricephora*. These are all shining, blue-black insects with brilliant red spots and

bands on the wing-covers, some of which spots widen out, or run together so as to make these organs almost uniform red, or they become reduced so as to leave the surface almost plain black. At least four of these can safely be placed as mere color varieties of *T. sanguinolenta*, from which they should not have been separated. South America is rich in beautiful species of this group, and Africa and the East Indies have superb forms of still other genera; but our space forbids further notice, however interesting these might be.

Turning to another sub-family, the Aphrophorida, we meet with smaller insects, often of much narrower form, with the vertex nearly as large as the prothorax, and the latter curved on the front margin, and either notched or concave behind. The eyes are commonly deep-seated, longer than wide, and placed obliquely. The scutellum is acuminate; and the legs are stout, short, armed with two thick spurs on the outside of the hind shanks, while on the tips of the latter and on the edges of the tarsal joints there are close-set, small teeth.

Here are placed the froth-bearing hoppers, *Aphrophora*, *Lepyronia*, *Ptyelus*, and their numerous allies. They compose a host of mostly brown, clay-yellow, or grayish species, of medium or small size, inhabiting all but the coldest climates of the earth, and being generally present wherever pine or willow is found to flourish. *Aphrophora* is represented in the United States by *A. parallela*, a brown insect marbled with still darker brown, with a pale streak along the middle of the head and running back upon the prothorax. There is an oblique, broken, short, white band upon each wing-cover, and two short streaks of white placed a little further back. It measures from one-third to one-half an inch to the tip of closed wing-covers. Its general color matches well the bark of pine trees, upon the branches of which, especially of the white pine, it may be found from June until late in autumn. In May and June the larvæ live covered by masses of white froth which the insect produces by expelling from their beaks the juices drawn out of the tree. These little accumulations of bubbly fluid may often be seen in the midst of a bunch of the pine needles, where the insect has resorted for its sustenance.

It is replaced on the west of the Rocky Mountains by a similar species of equally large size, the *A. permutata*, which inhabits the pine regions from Vancouver's Island to near San Francisco.

The *A. quadrangularis* is a smaller species, belonging to the eastern half of the United States. It is of a grayish color, crossed on each wing-cover by a triangular black line, behind which, at tip, a small streak and spot of the same color appear. It also lives, enclosed by a mass of froth, on various plants and shrubs. Occasionally a little mass of this fluid may be seen sticking to the stalk or leaf of grass in the fields or upon blackberry twigs near the fence corners. A notion prevails among the negroes of the southwestern counties of Maryland that the smaller horseflies of the forests are produced from these little accumulations of froth which they notice attached to bushes in the vicinity.

Lepyronia sordida is marked like the preceding, but may be recognized by the much stouter head and body, and by being much more hairy. It inhabits the northern and western States, and extends far south into Tamaulipas, Mexico.

Ptyelus is a smaller, parallel, grayish, or clay-yellow form. Various species inhabit the northern parts of this continent, some of which occur also in Europe. The *P. lineatus* abounds on the grasses and low plants of prairies and meadows, especially in damp situations. This species may be recognized by the narrow brown, double

streak on the head and prothorax, as also by a slender line of the same color near the costal margin of the wing-covers, the margin itself being white.

Clastoptera is an allied genus, quite in contrast with all of the foregoing by its blunt head and plump body. Its extreme forms are almost hemispherical, are all of small size, and inhabit both North and South America. One of these short, round forms is the *C. proteus*. Its most distinctly marked examples are deep black, highly polished, marked with two yellow bands on the vertex, and one on the thorax, with two oblique stripes on the base of the wing-covers, and a cross-bar near the tip. A black spot generally occupies the base of the pale brown membrane, and there is a black dot near the tip. It measures about two-twelfths of an inch to the tip of wing-covers. As the specific name indicates, it is really protean in the variation of its colors,



FIG. 309. — *Clastoptera proteus*.

passing through all modifications of pattern in marking, and including even the extremes of color, such as plain black or nearly uniform yellow. On the eastern coast of the United States it lives upon the cranberry vines, or upon blueberry bushes in swampy places. It is found in the adult state from June to August, and is distributed from Lower Canada to Florida and thence to Texas. A few specimens have been captured in Washington Territory, and it occurs also in Minnesota and Iowa.

Another species of more elongated form, the *C. obtusa*, is very common upon the leaves and twigs of black alder in July, and continues all through the warm weather until late in autumn. It is of a claret brown color above, marked with two pale bands on the vertex, two on the prothorax, and a wavy, broader band on the wing-covers. The membrane is often whitish, the waved band is extended exteriorly, and there is a pale, V-shaped figure on the end of the scutellum. It is a little larger than the preceding; inhabits many parts of the eastern side of the United States, and is distributed southwest into Texas and Tamaulipas, Mexico.

We now reach the wide-spread and exceedingly extensive family JASSIDE. The forms here included are generally more slender than those of the preceding group, but in some cases there is a close resemblance between them. These may, however, be recognized in most cases by the exceedingly long hind-legs, the shanks in this case being nearly or quite as long as the abdomen, curved, and armed with a series of long spines exteriorly, and with shorter, close-set teeth and bristles on the lower and inner margins. Their form is commonly long and slender, often spindle-shaped, with a large transverse prothorax not much wider than the head. The front is generally an oblique, cross-ribbed, inflated prominence, with the cheeks touching the anterior coxae, but rarely, if ever, restraining their movement. They have a rather large triangular scutellum; the wing-covers curve over the sides of the abdomen, appear as tapering towards the tip, and the membrane is well distinguished from the more leathery corium.

The species are world-wide in their distribution, many small and inconspicuous ones being able to live on the scanty vegetation of the Arctic regions; but the large and richly colored forms inhabit the tropics of both hemispheres, and are especially numerous in the warm parts of South America. At least two sub-families of unquestionable distinctness belong to this great group. The first of these the Jassida, are generally more or less wedge-shaped, with the costal margin of the wing-covers a little curved, and the vertex more or less crescent-shaped or deltoid. But the position of the ocelli will usually serve to distinguish these from the members of the following

sub-family. These latter organs are placed upon the rim of the vertex close to the eyes, or on the front, but never upon the upper surface or vertex proper.

The old genus *Jassus* of Germar and various other authors has been shown by Dr. Stål to be erroneously founded, and that the real Fabrician *Jassus* is the *Ciclidia* of later authors, so that a dismemberment has become necessary, and the characteristic species must be placed in new genera. One of these latter is *Allygus*, which is represented in this country and in South America by a large number of gray and brown mixed species having a broad, nearly triangular vertex, with the apex usually a little recurved.

A common form on the willow and other plants in damp places throughout the eastern half of the United States is the *A. irroratus*. It is of a pale horn yellow color, but when alive and very fresh is ivory white, clouded with pale brown. Its face is streaked each side, and closely flecked in front with pale yellow on a brown ground, but is broadly pale next the origin of the rostrum, and on the outer cheeks. The vertex is closely reticulated with brown, with an obscure dark line on the middle and two narrow, transverse, ivory yellow spots each side on the front edge. There is also a series of seven black specks on the costal margin, two or three on each edge of the clavus, and the surface generally of the corium freckled, and spread with groups of branching, slender, brown lines. The fore and middle thighs are crossed by three uneven dark bands or spots that are sometimes confluent; the hind ones are streaked, and at tip twice banded with darker brown, while the tibiae are interruptedly barred, and between the spines dotted with the same color. Usually the sutural margins of both pectus and abdomen, spots upon the coxae, and tips of the tarsal joints are banded with paler brown. The dorsal surface of the abdomen is commonly blackish, at least on the disc; and the males are generally darker than the females. It measures rather more than one-fourth of an inch to the tip of wing-covers. In Maryland and the adjoining States it is somewhat common from early in July until near the end of October.



FIG. 310.—*Allygus irroratus*.



FIG. 311.—*Cicadula vittifera*.

Other species, of the same colors, and marked in very nearly the same manner, are met with in various parts of North America. A reticulate veining in the areoles, accompanied by a larger number of cross-veins than usual on the costal area, disc, and clavus, will serve to separate this genus from its nearest relatives.

Near this may be placed a most pernicious but strongly marked smaller species, *Cicadula vittifera*. This genus differs from the preceding in lacking the cross-veins and reticulations of the wing-covers. It has few areoles; those next the tip are very long, while the four apical ones are longer than in *Allygus*. The species is pale yellow, polished, banded with black on the upper surface of the abdominal segments. The face is brighter yellow, crossed each side by a series of curved, brown lines, the outer cheeks marked with two long, brown spots, and the front with a black dot on each side near the reddish ocelli. The vertex has usually a pale brown, transverse cloud, marked behind by two darker spots, and beyond which, on the prothorax, is a transverse, curved series of fuscous dots. Scutellum bright yellow, inscribed each side of base with a brown line, behind the middle with four small irregular spots, and at tip with a white line. On the sternum the black color occupies the discs of the segments, while the two anterior pairs of femora are interruptedly striped, and the spine-sockets of the posterior shanks are brown. The wing-covers are translucent,

more or less tinged with brown or yellow, and the veins are thick, brown, sometimes clouded with brown each side, and the costal vein is whitish. It measures about two-twelfths of an inch to the tip of wing-covers. This insect swarms in wheat-fields, meadows, and low spots along the edges of oak woods, in spring and late summer. It is reported to be very injurious to wheat and oats, as well as to the grasses in various parts of the southern States; but it is by no means confined to that region, for I have secured specimens from all the Atlantic States south of New York, and even from Colorado near the Rocky Mountains.

Other forms, some of them very pretty, described by Mr. Say and others, belong here; but which we can now only mention by name. They are *Thamnotettia clitelarius*, *T. seminudus*, *T. kennicottii*, *Grypotes tergatus*, *G. unicolor*, and the gray-mixed or brown-spotted little hoppers with deltoid heads, belonging to *Deltocephalus*, but described by Dr. Fitch under the genus *Amblycephalus*.

One small assemblage of genera within this group yet remains to be mentioned, deserving attention from the fact that some of the species swarm upon vines and other productions of the garden and field, causing widespread injury and ruin by exhausting the sap of the plants. One of these is the genus *Erythroneura*. It is composed of quite small, very slender, spindle-shaped insects, with few cells to the wing-covers, and these, four in number, are confined to the tip. *E. vitis* is ivory yellow, marked with two lines on the vertex; a band across the back part of the pronotum, the scutellum, the wing-covers at base, and a band across their middle are all bright crimson. Occasionally there are some red marks behind the middle band, and the tips are more or less blackish. This species varies in an uncommon degree. It lays its eggs in April and May upon the tender leaves of the vine, and by the middle of June swarms in the perfect state upon the under-side of the leaves. It inhabits the Atlantic region from Massachusetts to Georgia, and spreads west into the Mississippi valley.



FIG. 312.—*Erythroneura vitis*.

In the last sub-family of the Homoptera we reach the Tettigonida. These are mostly small or medium sized insects with long bodies, an expanded face upon which the front is set as a prominent ridge, the antennae bristle-shaped, set upon thick basal joints, and placed in a cavity beneath the rim of the vertex. The position of the ocelli upon the vertex, instead of in front, will at once separate these from those of the foregoing group.

At the outset of this assemblage we find a few forms which by their plump proportions are brought strongly in contrast with the general type of the group. One of these, which might be mistaken for a *Chastoptera*, is the *Penthimia*. Here the crown of the head is broad, nearly quadrangular, and curves down bluntly over the face. It has large triangular eyes, and ocelli placed pretty far forward. Most of the upper surface is transversely wrinkled, and the wing-covers, excepting the disc of the corium, are closely punctate. The face is moderately broad, somewhat covers the side of the fore coxae, and the hind shanks are much curved. Our native species, the *P. americana*, is of a chestnut brown, sometimes very dark, or even pitch-black, with an irregular whitish patch, enclosing two or three dark spots, on the membrane. When fresh it is seen to be invested with bronze-colored pubescence upon the wing-covers and base of the scutellum. Several marked varieties occur, one of which has two red dots on the black vertex and a spot of the same color on each outer angle of the prothorax. It is about one fourth of an inch in length to the tip of the wing-covers; and it lives on the sugar maple in the northern States and Canada, but is found upon small

trees and bushes of various kinds in the middle, southern, and southwestern States. In Montana, Dakota, Illinois, and Minnesota it is sometimes quite common upon plants growing in plains or prairies.

Acrocephalus belongs here, and may be recognized by its boat-shaped figure, gray and brown mixed colors on a pale yellow ground, as well as by the coarse surface, thick wing-covers with stout veins, and the shovel-shaped vertex, with a thick, smooth margin. *A. nervosus* is a pale clay-yellow species, grayish, freckled with brown, and having a few angular, whitish lines on the wing covers. The male is more uniformly brownish-yellow, with a pale band across the prothorax. It measures about one fourth of an inch in length, and inhabits both Europe and North America. Specimens may be swept from thistles, golden-rod, and various kinds of weeds in fields throughout the northern States. Thus far only three or four species of this genus have been found in the United States, but in Europe more than a dozen species have already been discovered.

A very large assemblage of forms belongs to the genus *Gypona*. It appears to have no representatives on the eastern continent, but already more than one hundred species have been described from the different parts of North and South America. The best known type of this genus is the pea-green *G. octolineata*. It is marked on the head by eight yellow lines, which continue back upon the prothorax. Its head is broad, shovel-shaped, a little peaked at the very tip. When long dead, or weather-beaten, the color changes to a greenish yellow, and the stripes become pale or soiled yellow. It measures nearly half an inch to the tip of the closed wing-covers. This species lives upon low plants, solidago, blackberry, willow, and small bushes in low grounds. It is also widely distributed, being found from Canada to Florida, and west to Minnesota, Kansas, and Texas. A variety is sometimes met with that is tinted bright scarlet, especially upon the veins of the wing-covers, and between the stripes of the head and prothorax.

Closely related to this genus is the beautiful and odd *Hecalus*. In it the head is protracted forwards in a long, shovel-shaped, thin plate, with the ocelli placed on the back part of the vertex. The wing-covers are nearly parallel-sided, with straight veins and two series of apical areoles, those of the marginal series being very short. There are also two veins upon the clavus.

A very beautiful example of this genus is the *H. lineatus*. It is pale green, with four orange lines on the vertex, which are continued back upon the prothorax and scutellum. The wing-covers are opaque, with orange veins, and the costal margin is recurved, and either white or pale yellow. It measures somewhat more than one third of an inch in length, and was captured upon grasses in the cranberry swamps of New Jersey, early in the month of August. A single specimen was taken by myself when sweeping marsh reeds on the island of Nantucket.

Spangbergia vulvulata is another fine insect, which generically approaches very near to the preceding. It differs, however, in having only one vein upon the clavus, and only three areoles to the disc of the wing-covers. It is of a delicate yellow, with two short, oblique, crimson lines on the long, foliaceous head, and three lines of the same color on the prothorax. The wing-covers are greenish or yellowish white, with the veins rose-colored or orange. It is a little smaller than the preceding, and is distributed from Texas to Bahia, Brazil.

Other related forms are uniform grass green, with shorter, less foliaceous head, as in *Parabolocratus viridis*; or with extremely long, foliaceous head, and dull clay-yel-

low color, such as is seen in *Dorycephalus*. *Xerophloea* is another allied genus, which is marked in the United States by the pale green, roughly punctate, angular-headed, and coarse-veined *X. peltata*. It is a broader form than either of the preceding, about as long as *P. viridis*, and is distributed from Massachusetts to Rio de Janeiro, Brazil.

Omitting all the minor groups which enter the family at this place, and which include hosts of genera and attractive species in all the temperate and warm regions, we reach the largest and most heterogeneous part of the group, formerly included in the inadequately defined genus *Tettigonia*. This overloaded genus has recently been divided into numerous others; but our space will admit the mention of only a very few of our American types.

A very beautiful representative of this group is figured on the plate at the head of this article. It is the *Aulacizes quadripunctata*. Its head, thorax, and under-side of the body are blood red, while the wing-covers, dorsal surface of the abdomen, middle of the venter and breast, hind margin of the prothorax and a spot near the front margin, three spots on the vertex and two on the face are purplish black. It is a native of Brazil, and is rather common on low plants in the vicinity of Petropolis.

The genus *Aulacizes* has a bluntly conical head, with a wide gutter along the middle line next the tip of the vertex. *A. guttata* is a fine example of this genus inhabiting the United States. Its upper surface is made rough by coarse punctures and wrinkles, on a dark brown ground flecked with yellow, while large marks on the costal margin of the wing-covers are of a brighter yellow. A very decided polish renders the clear carmine of the dorsal surface of the abdomen very vivid, and this is brought into exquisite relief by the translucent brown color of the wings. The underside is ivory yellow, red at tip, has black specks upon the face and breast, and a blackish area upon the venter which is interrupted by six or eight orange spots arranged in pairs. It measures nearly half an inch in length. Specimens occur singly upon low plants in damp situations near woods, during late summer and early autumn. It is distributed from Long Island to southern Florida, and is more common in the south than farther north.



FIG. 313.—*Aulacizes guttata*.

Rhaphirhinus comes next, and is remarkable for the sword-like projection stretching out from the tip of the head. *R. fasciatus* is a beautiful purplish-brown insect, which has the wing-covers crossed by four more or less oblique, or broken, orange-yellow bands; and with another of the same color on the prothorax, and two spots on the base of the vertex. It measures three-fourths of an inch from the tip of the sword to the end of the body. This is a Brazilian species, which appears common in various parts of the Amazonian basin, upon plants and bushes in low grounds.

Ciccus pervirgatus is in appearance almost a repetition of the foregoing. It lives in the same country, but lacks the sword at the end of the head.

Proconia has numerous conspicuous species in Central and South America, and the genus is indicated in North America by five or six types of the common pattern. It differs from the preceding genus chiefly in having a more blunt head, wider across the eyes than the thorax, and in having no gutter on the front of the vertex.

One of these, *P. undata*, is common in the United States, is distributed from Massachusetts to southern Florida, and west to Texas. Its body, head, fore part of thorax, scutellum, and legs are bright yellow, with circular or curved lines of black on the head, thorax and scutellum. The under-side of the abdomen is banded, and the breast

and legs speckled with black. The wing-covers are bluish purple, when fresh, coated with whitish powder. It measures about one half of an inch to the tip of the wing-covers, and lives upon wild grapevines, blackberry bushes, and various other plants in fertile soil about the edges of woods.

Proconia costalis is a small, brownish black species, with a white line passing around the blunt head, and continuing along the sides to the end of the abdomen. The head, thorax, and all beneath are sprinkled with white; the wing-covers red, lined with black and yellow, and the legs are black striped with white. Its length is about one third of an inch to the tip of the wing-covers. It is distributed from the extreme north, near Mackenzie River, throughout all the low country as far south as Mexico, and occurs occasionally in most parts of the Atlantic region not far from the coast. On the great plains and near the Rocky Mountains it swarms upon the buffalo grass, especially in places which are somewhat damp, or near water.

Its larvæ and nymphs are very conspicuous, having a great, stout head attached to a rapidly tapering body, of a pale yellow color striped with dark brown.

The genus *Dicrocephala* is represented in North America by grass green, or pale green, spindle-shaped insects, which may be always recognized by the long, deltoid head, as seen from above. The head is generally marked with a few areolated, short, black lines, and has the fore part of thorax and scutellum of a yellow ground color. *D. mollipes* has the abdomen, legs, and body beneath pale-clay yellowish, the lines across the front and those of the vertex black, the wing-covers margined with yellow, especially upon the costa and suture bounding the clavus, and the veins of the wing-covers blue, while those of the cells of the membrane are green. It measures about one third of an inch in length, and sometimes swarms upon grass, mint, and low herbs in damp spots adjacent to watercourses. The salt marshes of the Atlantic States furnish places of shelter for it, where it may be found on the reedy grasses, in all stages, from June until October.

Other species bearing a close resemblance to this, but differing in the shape and proportions of the vertex and in its pattern of marking, may be found in British America, the northern States, in Florida, Texas, Mexico, and California.

SUB-ORDER III.—HETEROPTERA.

This division differs from the Homoptera in the composition and position of the wing-covers, and in the direction of the head. The wing-covers are laid flat on the back, and are composed of three well-separated portions, — the corium, or dense part extending from the base; the clavus, which bounds the scutellum; and the membrane, a thin end piece which intimately overlaps its fellow, and is distinctly veined. Besides these, there is sometimes a triangular piece at the end of the corium, next the base of the membrane, which is particularly distinct in the family Phytocoridae and its allies, called the cuneus. All of these parts are modified in a great variety of ways, being either narrow or wide, long or short, expanded behind, toothed, hairy, or bald, and crustaceous, coriaceous, or even semi-membranous throughout the larger portion.

The head is placed horizontally, being let into a socket formed by a hollow in the front end of the prothorax; and the rostrum (usually of four joints) is attached to or directly beneath the tip. An exception to this occurs in the Coreidae, where the head overlaps the front of the prothorax, and is secured there by a narrow gullet, as in horse-flies and some other Diptera, and in certain dragon-flies. The prothorax is

always a free, large segment, bearing the same relations to the other segments as we see in the Coleoptera, and, like them, having a distinctly segmented scutellum. There are usually two ocelli, never three, situated on the vertex, but these are absent from a few genera, and also from the young stages of all. A marked difference in the depth of the body is to be observed in the various groups. Some, such as the Scutelleridae, have the greatest convexity of the surface above; others, like the Coreidae, are most convex beneath. Numerous intermediate modifications of these surfaces occur, carrying with them others which affect the parts of the segments, and of the organs connected with them. Examples of each of these will be brought to view as the genera are taken up, and some of the more remarkable forms will be described.

The group at large is divided into two great sections, based upon modifications of the antennæ dependent upon the habits and kind of element in which the creatures live. Lowest and first of these appear the aquatic kinds, composing the section CRYPTOCERATA, so called from the nearly concealed position of the antennæ, which are short, and placed underneath the head in a cavity near the eyes.

The family CORISIDÆ is the most aberrant of the order, being composed of insects whose mouth is flattened out, shortened, directed obliquely backward beneath, and the rostral setæ are thrust through a little hole above the actual end of the clypeus, and not as usual at the tip. Instead of being let into the end of the prothorax, the head overlaps and fits intimately against it, and the fore-tarsi, called palæ, are flattened like the blade of a pen-knife, are set with bristles on the inner thin edge, similar to a comb, and end in a slender nail at the tip. A most striking feature also appears in the males of *Corisa*, where the serial parallelism of the ventral segments is disturbed, and on one side broken into pieces as if by explosion.

This very comprehensive genus includes the greater part of the family, and is composed of insects having a long elliptical form, with the front end widest and bluntly rounded. The sides are generally parallel, not much curved, and the membrane is almost of the same texture as the corium; the head covers the whole fore end of the prothorax like a broad crescentic mask, and the face is carried downward in a wide, nearly flat, blunt triangle, the clypeal part of which is crossed by sutures, marking off the transverse rostral joints. On the under side only one suture is conspicuous in the clypeal region, which gives the apical segment a valvate form, like the labium of a mandibulate insect. Nevertheless, the gular middle line is swollen, and, by close examination is seen to be composed of four joints. The prothorax extends back and hides the scutellum. The antennæ are moderately long, tapering towards the tip, and composed of four joints, of which the third is longest, more or less thickened at the outer end, while the fourth is almost setaceous, and terminated by bristly hairs. A marked



FIG. 314. — *Corisa interrupta*.

contrast exists between the middle and front legs in the length of the joints. In the former the femora and tibiæ are long and slender, the femora longer than the tibiæ and tarsus united, while the posterior legs are made about equally long by the lengthening of the tarsus, which is a flat paddle composed of two joints, closely resembling the same organ of a crab. Our largest North American species is *Corisa interrupta*. It is one of the moderately broad

forms, dark brown above, tile yellow beneath and on the face and legs. The prothorax is polished, minutely engraved punctate, crossed by nine or ten yellow narrow lines, blunt behind, and margined with yellow. The clavus

is crossed by zigzag lines at base, and by others which become more slender and straight towards the tip. Similar lines on the corium are more sinuous and interrupted towards the inner margin. The costal area is blackish at base, and there is a spot of the same color behind the middle. Each side of the prosternum there is a large black spot, and a fuscous cloud on the middle and posterior coxae. The pale are curved, a little widened in the middle, and acute at tip. It measures fully five-twelfths of an inch to the end of the wing-covers. The pale of the male are cut off obliquely at tip, and the sides are not curved, but nearly parallel. In this species the frontal fovea is oblong, not very deep, and extends up to a point about the middle of the eyes.

These insects are truly aquatic, but they occasionally leave the water, particularly when they find it to be drying up, and during their nocturnal flight are drawn to the lights in our houses, into which they dash with headlong precipitation. They frequent almost every variety of water, from the briny lakes of Utah and California to the clearest mountain streams of our northern territories; but they are not confined to this country, and are distributed from the sub-arctic regions of both hemispheres to southern Africa on the eastern, and to the Argentine Confederation on the western continent.

The greater number of species thus far known have been obtained from Europe and North America. In the middle States there are summer forms and winter forms. The latter are chiefly those which belong to Canada and the extreme north, while the others have a local distribution concurrent to a certain degree with the temperature of the water in which they are hatched. One of these, the *C. interrupta*, may be found in puddles and sun-heated streams from New York city to Rio, Brazil. In Mexico, Central America, the West Indies, and southwestern United States there is an assemblage of species which is rendered quite remarkable by the pale dull vermiculate markings which prevail over nearly the entire hemelytra. About one hundred and fifty species have already been discovered, and new ones turn up wherever explorations are conducted with intelligent care.

Few insects are more sprightly, and the aquarium acquires a new interest by the introduction of these easily obtainable creatures. They live on the bottom in puddles, ponds, and running waters, but it is especially of interest to observe their habits upon the bed of a bayed-out part of a stream, where there is no current. In such places they may be seen at home, balanced with the neatest delicacy by the tips of their intermediate feet, stationed in the midst of their young at intervals of a few inches; then, by reason of some disturbance, dashing away with rapid strokes of the posterior paddles, and arising to the surface, perchance to take in a fresh supply of the external air. There, resting horizontally for an instant, with the long middle feet extended forward, the sides and ventral margin become glazed with an air-film which shines like translucent silver. The head and prothorax are capable of much freedom of motion, and at such times both of these are lifted to admit the air to the dorsal spiracles, which are situated on the sides above the legs. The genus *Nigara* also belongs to this family, and may be distinguished from *Corisa*, by the small but uncovered scutellum.

The family NOTONECTIDÆ is composed of perfectly aquatic forms, differing from all others in the persistent habit of swimming on their back. They are much deeper bodied than other Heteroptera which live in the water, and while being oval in form with the apex of the wing-covers conical, have the convexity of the surface above.

Their eyes are large, reniform, twice sinuated on the outer side, and project a little way over the front margin of the prothorax. The rostrum is elongate, conical, acute, and composed of four joints. Ocelli are absent; the vertex is a broad wedge with the narrow end behind, and the face curves downwards. The prothorax is transverse, moderately convex, gradually narrows anteriorly, and has the lateral margins sharp, projecting. Next the lower sinus of the eyes, the tapering antennæ project upwards, and are formed of four joints, of which the basal one is very short, the second long, stout, rounded, the third still longer, fusiform, narrower at tip, and fringed with curved bristles. The membrane is here well distinguished from the corium, and the legs are all long; the tarsi are three-jointed, with the basal joint minute, and armed with two slender, curved nails, of different lengths, on the anterior and intermediate hairs; the posterior pair of legs is longest, somewhat flattened for swimming, and thickly fringed with long silky hairs on both margins of the tibiæ and tarsi. On the middle line the venter is distinctly ridged, and invested with long hairs.



FIG. 315. — *Notopecta glauca*.

Several genera have been defined in this family, but only three are well known in North America. The first and commonest of these is *Notopecta*, which may be known from the other genera by the distinctly marked membrane, by the broad body accompanied by a scutellum about as wide as the pronotum, and by the narrow curved front, without swelling or prolongation. The common *N. undulata* is widely distributed in North America, and is a very variable species. Some specimens are nearly all ivory white above, with the dark dorsolum showing through the base of the prothorax, with dark brown eyes, and some dark cloud-like patches on the sternum and venter. More commonly it has a broad, zigzag, interrupted black band across the base of the membrane, and one or two oblique streaks nearer the base of the corium, occasionally also on the inner margin of the clavus. The disc of scutellum, dorsum of the abdomen, and sutural margins of the ventral segments are also often black. It measures one-third to nearly one-half of an inch in length, and inhabits muddy pools, ponds, and bodies of still water in most parts of the eastern United States, and extends southwest into Mexico. Various other species inhabit America, one or more occurring in every country as far south as Patagonia. Several others belong to Europe, Asia, and northern Africa, but the most beautiful of all is the *N. mexicana*. This is a large, robust species, with bright red wing-covers, black membrane and scutellum, and ivory yellow prothorax, head, and legs. A variety occurs in which most of the red color is replaced by black, or yellow and black in unequal proportions. It measures fully one-half of an inch in length, and is distributed from southern Mexico to central Arizona.

Most of the species already known have a white or pale ground color, marked with yellow, black, and smoky brown, and those of Europe, while being specifically distinct, offer varieties similar in pattern to those of the United States. All are capable of sustained flight, and often go long distances in search of a congenial body of water when the food gives out or the water shallows in the place where they were born. The incessant activity of these insects in the water is very remarkable; from early morning until sundown, and even later, they are rising with sudden jerks from the bottom to the surface, and then diving with the hind-legs in rapid motion. A spray of grass or projecting stick at the top of the water serves as a balancing point by which to sustain themselves at pleasure. Their appetite, also, seems almost insatiable. Every insect that they can overcome falls a prey to their quick grasp, and when once

a victim is seized it is held with unbending tightness until all the fluids of its body are completely withdrawn. These insects resent handling, and if not cautiously picked up, take advantage of the first opportunity to plunge their beak deeply into the flesh of their captor, and thereby produce a keenly smarting pain which lasts for several minutes.

The genus *Anisops* belongs here, and is composed of much more slender forms than the foregoing, in which the fourth joint of the antennæ is longer than the third. The males of some of the species have, in addition, an acutely produced forehead. Our best known North American species is *A. platycnemis*. It may be known from the others by the unusually widened fore-tibiae of the males. The color is ivory white or pale yellowish, sometimes with the scutellum and base of the dorsal surface of the abdomen bright orange; the venter, breast, end of abdomen on the dorsal surface, upper sides of the femora, and dorsum of the thorax beneath the prothoracic outer shell, are more or less black. The wings are milk white, and, together with the wing-covers, much longer than the abdomen. It measures about one-fourth of an inch to the tip of the wing-covers. Thus far it has been met with from Maine to Cuba; it is also found as far west as Illinois, and from thence to Texas and over the Rio Grande to Tamaulipas, Mexico. In the State of Maryland it seems to prefer cold spring-water, in which I have found it generally late in October, after the frosts had set in.

The genus *Ploa* contains the pigmies of this family, none of them much exceeding a line in length. Only one species, *P. striola*, has thus far been found in the United States. It is a much deeper-bodied form than either of the preceding, lacks the membrane of the end of the corium, has the ends of the wing-covers high and cut obliquely, the eyes brown, and with a reddish-brown streak on the middle of the front, and sometimes a dusky spot near the tip of the corium. It has been found in Massachusetts, Illinois, Kansas, and Texas. The genus is interesting from having a minute supplementary joint attached to the side near the tip of the long and stout third joint of the antennæ. It is a highly polished, coarsely punctate species, with a wide, bluntly curved head, and short legs.

Another family of truly aquatic insects is the NEPIDÆ. It is composed of flat, elliptical or elongated, fuscous or pale brownish species, with legs fitted for walking rather than for swimming, and with the fore-tibiae curved, and carrying a long, one-jointed slightly bent tarsus. These two last, united, fit into a channel of the long and wide femora, like the blade of a pocket-knife. The head is narrow, and surmounted on each side by a prominent oval eye; the membrane is well distinguished from the corium, and the abdomen is terminated by two long, respiratory half-tubes, which, applied together, serve as a pipe to convey the air to the interior of the abdomen.

Our native species, *Nepa apiculata*, is of a dull fuscous gray color, with the base of the abdomen above more or less tinged with reddish. It is of an elliptical form, blunt in front, with a ridged middle line on the vertex, and with three short raised lines on the prothorax, each side of a longer one on the middle. The surface and margins of the thorax and head are roughly granulated, while these, together with the scutellum and corium, are rough and closely covered with stiff, short pile. The anterior femora have no tooth on the inner angle, but instead there is a prominent elbow, forming a wide expansion for the sides of the deep gutter. The wings are smoke brown, with darker veins. This species closely resembles the European one, and meas-



FIG. 316. — *Nepa apiculata*.

ures about two-thirds of an inch to the end of the abdomen, while the respiratory tubes are a little more than one-fourth of an inch in length. It lives beneath stones and rubbish in bayed-out places of our streams on the eastern side of the United States. As no specimens have yet been reported from the region west of the Mississippi basin, we are unable to record its distribution beyond the limits named; but within that region it extends from Albany, N. Y., to eastern Georgia. As far as its habits have been observed, it seems to delight in very muddy spots, and buries or covers itself by the leaves and dead twigs which lodge in the shallow cavities along our inland streams.

This genus is remarkable for the contracted condition in which the abdominal stigmata are often found to be. Respiration would seem to be effected chiefly through the apical tube, and there are large bladders for holding air, placed directly within the mesothoracic cavity, communicating with the dorsal stigmata by means of tracheal tubes.

The oriental countries, including Japan and the Philippine Islands, are tenanted by large, oblong species, not much wider behind than in front, which have a distinct tooth, or tubercle, upon the inner angle of the anterior femora, and very long respiratory tubes.

Akin to these are the species composing the genus *Ranatra*. These latter are, however, in strong contrast with all the others in their extremely elongated form and the simplicity of their integument. Here the fore-legs are raptorial, with the tibiae and one-jointed tarsi slender, curved, opposable at tip to the erect tooth which projects from the lower side of the femora. The other pairs of legs are exceedingly long and almost thread-like, with a pair of slender, long, curved nails at the tip of the tarsi. They have a short head, with a correspondingly short but very acute rostrum, and the antennæ, composed of three variously-shaped joints, are stowed away on each side of the throat. The first joint is very short, the second is longer and protracted transversely, the third is longest, fusiform, curved. The prothorax is about one-half as long as the wing-covers, somewhat cylindrical, but widened at base and a little contracted in the middle.

Two species inhabit the greater part of the United States, *R. fusca* and *R. quadridentata*. The former is a fuscous grayish insect, more slender and generally smaller than any other American form now known, which inhabits ponds and the quiet parts of streams in New England, the Atlantic States, and the gulf region as far west as central Texas. It delights to live among the muck and rubbish of shallow fresh water, and may sometimes be seen lodged on the leaves and stems of the pond-weed leaves in basins of cold spring water. During the warm summer weather it may be seen at times resting on the bottom, stilted on its long legs, with the respiratory tube projecting upwards, just a little outside of the surface of the water. At such times it rests motionless for intervals of an hour or more, but at other times it



FIG. 317. — *Ranatra fusca*.

searches for the eggs of pond fish, which it destroys by drawing out their contents, and it occasionally attacks the young fish of other kinds, grasping them with its curved fore-claws and sucking their blood.

Our largest species is *R. quadridentata*. Its natural color is pale dull ochreous, with the dorsum of the abdomen reddish and longitudinally marked with smoke brown. The fore-femora have a long tooth beneath, nearly one-third way from the tip, and a notch at the end bounded behind by an angular prominence (described as a tooth by some authors) on each side of the grooved line. A marked feature of this species is noticeable in the length of the respiratory tube, which is as long as the abdomen and basal segment of the prothorax united. The male is somewhat smaller and thinner than the female, and may be recognized by the flatter, less hairy last ventral segment. This species is distributed from Albany, N. Y., to Sonora, Mexico.

Many other species belong to this genus. The most robust and the largest are those from Japan and China; the latter, *R. chinensis*, has the upper side of the abdomen black, with the side margins clay yellow. *R. fabricei* inhabits Cuba and the other Great Antilles, and is remarkable for having the respiratory tube one-fourth longer than the whole body. *R. annulipes* inhabits the tropics of South America from Demerara to Rio, and has the legs banded with fuscous. One species, the *R. linearis*, has the upper part of the abdomen bright red; it inhabits Europe. About twenty species are already known from the temperate and warm parts of the earth, and at present the eastern hemisphere, including Madagascar, Africa and its islands, seems to have the larger number of species. They may be regarded as the aquatic representatives of the Emesidæ, having habits likewise rapacious and carnivorous.

We now reach the family BELOSTOMIDÆ, which contains the largest Heteroptera now in existence. These are all wide and flat-bodied aquatic insects, of more or less ovate outline, furnished with powerful flattened swimming-legs, the fore-tibiae curved as in the preceding family, and fitted for seizing and holding tightly the victims (fish and other creatures), upon which they pounce from their hiding places in the rubbish or among the branches of water-plants. Their color is always some shade of brown, generally with some faint marks of fuscous or blackish, especially upon the legs. This group, as at present known, consists of about one dozen genera, distributed over most of the temperate and torrid climates of both hemispheres.

Here the head is much narrower than the prothorax, although the large triangular eyes sometimes project above and beyond its lateral margins; the front, including the base of the rostrum, is more or less long-conical, with the rostrum short and three-jointed. The antennæ are short, composed of four joints, and rest concealed beneath the eyes. Behind the wide, trapezoidal prothorax, a large triangular scutellum succeeds, varying much in length, but never equalling the former in width. Notable differences appear in the form of the metathorax, which in some genera is very narrow, while in others it is wide and extends on either side of the scutellum. The wing-covers are generally well separated into corium and membrane, and the former is usually furnished with numerous irregular meshed veins. A remarkable feature of all the genera is in the presence of a pair of flattened, narrow, strap-like appendages at the end of the body which are extensile, but not concerned with respiration, as in members of the foregoing group.

America possesses the largest and most conspicuous members of this group; while India, China, Japan, and northern Africa each has its characteristic representative. These belong to the genus *Belostoma*, and the chief of them all is the *B. grandis*, which inhabits the sluggish waters of Guiana and Brazil. As seen in collections it is a dull yellowish-brown insect, marked with dark brown on the fore-part of the prothorax, and on the disc of the scutellum, which has a tablet-like mark

bounded by raised lines before and on the sides, and also has a carinate line running down the middle. The under side is also more or less spotted and marked with fuscous, while all the femora and tibiæ are more or less distinctly thrice-banded with the same color. On the inner margins of the preceding, including the tarsi, as also the nails, a distinct blackish color prevails. The largest specimen that has yet been brought to this country measures four inches to the tip of the abdomen; but this is quite exceptional, since we rarely meet with individuals which exceed three and a half inches in length. This large one also measures nearly one inch and a quarter across the base of the prothorax. It is a formidable monster in the pools of Demerara, where it lurks on the bottom of the muddy pools which match its color, ever ready to grasp the unwary fish in the cruel embrace of its sharp hooked fore-legs, there to remain fixed until life becomes extinct with the outflow of its blood.

Scarcely less rapacious are the species inhabiting the United States. One of these, *B. grisea*, is the facile master of the ponds and estuaries of the tidal creeks and rivers of the Atlantic States. Developing in the quiet pools, secreting itself beneath stones or rubbish, it watches the approach of a *Pomotis*, mud-minnow, frog, or other small-sized tenant of the water, when it darts with sudden rapidity upon its unprepared victim, grasps the creature with its strong, clasping fore-legs, plunges its deadly beak deep into the flesh, and proceeds with the utmost coolness to leisurely suck its blood. A copious supply of saliva is poured into the wound, and no doubt aids in producing the paralysis which so speedily follows its puncture in small creatures. It is of a dull grayish brown, varied with fuscous, and more distinctly marked with a blackish patch each side of the prothorax, and on the sides of scutellum, and striped on the breast with three broad lines of the same color, which widen behind and become less distinct upon the venter. In this species the pectus and postpectus are yellow, and thus the black stripes are there brought out with greater distinctness. The legs are broad, and the femora and tibiæ are sometimes indistinctly thrice-banded with blackish. Usually the upper surface is smoother than in the other species which this most resembles. Its anterior legs are also longer, and instead of having the longitudinal groove on the front side of the femora, the surface is rounded off and more widely clothed than usual with stiff, short, velvety pile. A new sub-genus, *Benacus*, has been designated for this form by Dr. Stål, based upon the absence of the femoral groove, and presence of the velvety turned edge. It is much narrower anteriorly than the other species, *B. americanum*, which also inhabits the Atlantic region, and to which it bears some resemblance. The latter, however, has shorter and wider fore-legs, besides the femoral groove; and it lives in quiet, fresh, or brackish waters, having essentially the same habits as the preceding. Both of these insects have the usual caudal setæ, which are retractile, and are often concealed by being drawn within the last segment of the abdomen. The former is distributed from Lower Canada as far as the West India islands, while the latter ranges from Oregon and Washington Territory across the continent, and from thence south into Texas and Mexico.

B. indica is a pale yellowish species which inhabits China and India. It sometimes measures three and a quarter inches in length, and it has often been confused with the South American species first mentioned, to which it bears some resemblance. *B. colossicum*, from Cuba and Central America, is the darkest and heaviest built of the large species. It is very coarsely wrinkled and granulated upon the thorax and scutellum, and has a deep, bent, depressed line crossing the prothorax and bending towards the shoulders on each side. Its fore-femora are covered all over with very short, close-set

pile; and the whole make-up of these fore-limbs indicates the great power with which this species is provided for the holding of its prey. Europe is remarkable for the absence of these monstrous insects from her territory, one species only having been found, very unfrequently, in southern Turkey and Greece, and this being in reality a form which has its home more directly in Egypt and northern Africa.

Closely related to the foregoing is a group of species of much smaller size and more ovate figure, which belong entirely to the New World. These are members of the genus *Zaitha*, which, besides the form as above indicated, differ from *Belostomat* in the more prolonged, tapering head and longer rostrum, and in the antennae, which have the three transverse joints long, nearly uniform throughout in thickness, and becoming successively shorter as they grade towards the apex. The fore-legs are relatively shorter than in the preceding genus, the femora are compressed, broad; the tibiae are also compressed, but narrow and curved, with two-jointed, wide tarsi, armed with a long, curved nail at tip. The species are numerous, variable in width, depressed, very feebly convex above, with thick, leathery hemelytra, terminated by a rather narrow membrane, which is crossed diagonally by numerous simple veins. The caudal setae are also present in these, but are generally enclosed within the last ventral segment.

Our common native species, *Z. fluminea*, abounds in the mud or among the weeds of ponds and streams, being found from Maine to Georgia, and west to Missouri and Texas. It is a pale clay yellow, oblong-ovate insect, with a round scar on each side of the unevenly roughened prothorax, and the under side of the head, the coxae, inferior margin of the prothorax, costal margin of the wing-covers, and connexivum are pale testaceous. On the sides of the vertex, front of the prothorax, and tip of the scutellum the color is often pale yellow, while the adjoining surface is faintly washed with brown. The corium and clavus are olive brownish, and closely and finely punctate; the former is set with numerous irregularly-branching veins, and the membrane is tinged with bronze. On the fore-femora, both on the inner and outer faces, there is an interrupted series of wide black streaks; on the inner side of the other femora is a similar double series, not always distinctly marked; and the fore-tibiae have two dark spots of blackish brown before the middle. The tips of all the tarsi are dark piceous. This species usually measures about nine-tenths of an inch to the tip of the abdomen; and the female appears to be somewhat broader than the male. These are not so heavily built as the members of the genus *Belostomat*, but they have the same predacious habits, and grasp and hug their prey with the hooked fore-legs.

The equatorial regions of South America are the native places of many curious species of this genus. There the forms present the greatest difference in proportions, and the largest as well as the smallest are equally at home. The vast expanse of fresh water spreading throughout the basin of the Amazon and its tributaries during the rainy season opens wide avenues for these creatures, and accordingly we find them everywhere across nearly the whole width of the continent, represented by numerous species. Two very conspicuous and exceptionally large forms inhabit this belt; one, *Z. eumorpha*, is more narrowed in front than usual, and measures one inch and three-fourths from the front to the end of the abdomen. It is of a nearly uniform clay yellow color, with the reticulated veins of the corium dark brown, and some faint bands of brown across all the femora and tibiae. The other species, *Z. dilatata*, is remarkable for its breadth across the wing-covers and rapid narrowing towards the front. Its head tapers symmetrically in the front, the costal margin describes a large arc, and the submargin and veins are flecked with dark brown. On the front tibiae

four black bands are very conspicuous, as also one or two upon the tarsi; and the femora of the other legs are less distinctly banded and spotted with the same color. It measures one inch and nine-tenths in length, by one inch in breadth across the wing-covers.

At the same time this great basin, in common with Nicaragua, harbors the neatest pigmy of the genus that has yet been discovered. This is a pretty little species, with a purplish tint floating over its olive brown upper surface, the costal margin pale testaceous; and the underside of the body, together with the legs, also testaceous, and the latter variously banded with brown. Individuals of this form measure no more than half an inch in length, and many of them are still smaller. It is one of the narrow-bodied species, with eight simple nerves to the membrane, and may be called *Z. minuscula*.

All the forms of this genus, so far as their habits have been observed, are remarkable for securing the eggs, attached in a layer, to the surface of the wing-covers. There they remain fixed until the larvæ are ready to escape, or sometimes till a few of them have hatched out, when the insect shakes them all off and they fall to the bottom. Very shortly after leaving the egg they are ready to take nourishment; and if a young mollusc happens to be near it is instantly pierced by the rostrum of the insect and sucked to death. The eggs are attached to the hemelytra by a kind of glue which is impervious to water; but the method of placing them there has not yet been observed and recorded.

Other genera allied to these inhabit the southwestern States from New Mexico southward into Mexico and Central America. One of these, *Serphus dilatatus*, is common in parts of Arizona, California, and Mexico. It is wider and more bluntly ovate than in the preceding genus, has the head much wider in front, with very prominent eyes, the antennæ concealed in a deep enclosure next the eyes, composed of three joints, of which the second only is produced and angular towards the side. It is of a brown color like that of a dead leaf, and at the bottom of the water might readily be mistaken for such an object. Some specimens acquire a red color by being immersed in water stained by clays impregnated with oxide of iron. The membrane is quite short, but carried pretty far around the margin of the corium, and furnished at tip with two series of moderately long areoles. These insects capture their prey in the same manner as *Zaitha*, and have similarly curved fore-tibiæ, tarsi, and nails.

Abedus contains somewhat narrower insects than the preceding, having the same color and similar curved fore-tibiæ and tarsi; but with four-jointed antennæ, the second and third joints of which are produced sideways. Two species, *A. ovatus* and *A. breviceps*, are smaller than *Serphus*, but inhabit the same countries, and have the same habits. The eggs of all three of these forms are likewise glued to the back, as in *Zaitha*. *Diplonychnus* is represented in the East Indies, China, the Philippine Islands, and Java by a pale brownish-yellow insect, margined with white on the costa and sides of the prothorax. It is a very flat, ovate species, with numerous irregular cells on a rather long membrane, and measures about two-thirds of an inch in length. *Sphaerodema* is a broader, somewhat longer, similar form, which inhabits Bengal and other provinces of India. It has the costal margin of the wing-covers broadly depressed and pale; the lateral margin of the prothorax is also similarly depressed and pale. These two last genera have no representatives in America, and are strictly confined to the lowlands of the eastern hemisphere.

A single step in advance leads to the NAUCORIDÆ. Here, as in the preceding group, we notice flat-bodied, mostly oval insects, of smaller size, destitute of ocelli, having raptorial fore-legs; and with hind limbs fitted for crawling rather than for swimming, having tarsi of two joints, armed at tip with two sharp claws. The antennæ are composed of four simple joints, well concealed beneath the eyes; and the rostrum is short, three-jointed, acute, but covered at base with a large, transverse, plate-like labrum. These all lack the caudal setæ; and have the last segment of the abdomen well differentiated, so as to distinctly mark the sexes. They are fond of reedy and grassy quiet waters, where they creep about like the dytiscid beetles, creeping and half-swimming around and between the leaves and sprays of the submerged plants, and suddenly seizing any unlucky *Corisa* or other insect that happens to be within reach. The fauna of the southwestern United States is rich in the species of this group, and shares with Mexico and Lower California some of the most curious and beautiful of its species.

The most widely spread North American species thus far discovered is *Pelocoris femorata*. It has been distributed into the collections of Europe and the United States with the name *Naucoris poeyi*. It inhabits the whole eastern side of North America, from Lower Canada to Florida, and from thence to Cuba and other West India islands. This genus is closely related to *Naucoris* proper, from which it differs in the eyes being shorter, lunate, instead of tapering as they converge toward the front. The prothorax is transverse, more convex across the width than in length, curving in continuity with the head; and the head is seated into it up to the middle of the eyes. A curious feature is noticeable here in the anterior femora, which are broadly rounded at base, unevenly cordate, and attached to the coxæ at a point considerably removed from the basal end. The prosternum is raised into the form of a pyramid, and the mesosternum is distinctly carinated. When alive this species is more or less greenish testaceous, but after death it changes to a pale yellow, or horn brown. It has a black line across the base of the labrum; on the prothorax a dark brown quadrangular spot is seen on the middle next the front margin; each side of this is a wide triangle, composed of scattered dots, flanked by larger and still more remote flecks, and with short, almost black lines in a series across the posterior sub-margin; while the lateral margins are broadly pale. The scutellum is rough and almost covered by dark brown marbled lines. The slightly convex wing-covers are livid brownish, with two pale dots inwardly next to the base of the membrane, and the base of the flat costal margin is broadly pale testaceous. On the venter is a faint trace of silky hair; the sides of the abdomen are marked with six squarish, black spots, and the legs are ivory white, or yellowish. The anterior tibiæ are strongly curved, tinged with picuous, and there is a dot of the same color on the apex of the pairs of posterior tarsi. It measures a little more than one-third of an inch in length; and is often made to appear darker than its actual color by the carbonaceous matter which attaches to its outer surface when pushing its way among the rubbish at the bottom of ponds. It has an exceedingly acute rostrum, and uses it with great freedom upon small molluses, larvæ of dragon-flies, and other creatures which live in its vicinity. The unwary collector who handles incautiously the insects taken from the water with the dip-net sometimes finds a sudden sharp pain in his finger, caused by the puncture of one of these irascible little fellows, who is ever on the alert to inflict punishment upon those who withdraw him from his place of abode. This species hibernates at the bottom of pools and ponds, in places where it can find some depth of muck, and

especially where reeds or water-plants remain rooted through the winter. Upon the first approach of mild weather it leaves the winter retreat, moves actively about, and soon prepares to lay the eggs, which it glues to the submerged leaves and sprays of plants.

This genus is replaced in Europe by *Naucoris*, of which *N. maculatus* is the best-known species. It is a more oblong form than the preceding, of a pale testaceous color, clouded and marked on the head, disc of prothorax, and scutellum with chestnut brown, and the wing-covers are clouded, dotted, and freckled with darker brown; the connexivum has a series of brown spots, while the legs and under side are pale yellowish. It is of about the same length as our native *Pelocoris*, but less convex posteriorly. This species is distributed chiefly throughout France, but is also found in various parts of Algeria.

By far the most widely-distributed while well-known European species is the common *Ilyocoris cimicoides*. It is described in the manuals of entomology as *Naucoris cimicoides*. In this genus the mesosternum is raised into a high carina, the second joint of the rostrum is not covered by the labrum, the anterior femora are expanded downwards at base, and the fore-tarsi are destitute of a conspicuous nail. The insect is about twice as large as the foregoing; when alive it is of a yellowish green color, highly polished, the head has a pair of stripes on the middle, and the base two blackish parallel spots; the prothorax is obscured on the disc with dark, confluent spots, and small, scattered flecks, which are absent from the sides, middle line, and the transverse line near the base. The wing-covers are obscured with brown, excepting the wide depressed base of the costal area; the connexivum is crossed by brown lines at the incisures of the segments; the sternum and middle of the venter have some obscure, broad areas, and the spines at tip of posterior pairs of tibiae are more or less piceous. It measures rather more than half an inch in length, and is somewhat long-oval in outline. It is pretty generally distributed throughout Europe, being quite common in England, where it inhabits ponds and ditches in which aquatic plants grow freely. Its motions are described as rapid, and it swims well by using the two pairs of hind-legs. The eggs are said to be oblong, nearly cylindrical, curved, whitish, and cut off obliquely at their front end. They are likewise glued to the stems and leaves of plants under the water. Our attention is here arrested by the fact that this genus has several species in the tropics of Brazil, while in North America, where the climate agrees better with that of Europe, not a single representative of it has been found.

Probably the most beautiful form belonging to this group is the *Ambrysus*. It has a very distinct pattern of marking, accompanied by an exceptionally round figure, which gives it somewhat of a medallie appearance. Our most elegant species is *A. signoretii*. It is of a bright clay yellow color, paler beneath, with ivory yellow legs and labrum. The head is deeply seated in the prothorax, is bluntly produced behind, and sinuated each side, with broad, lunate, brown eyes, which are more than half enclosed by the wide, flat sides of the pronotum. The vertex is thinly, unevenly spread with brown; there is a brown double streak down the middle, running into a double spot of the same color at base. On the depressed sides and at base the pronotum is pale, very minutely punctate; while on the disc it is marked with two large triangular, emarginated spots composed of brown dots, and between these two, in front, it is transversely



FIG. 318.—*Ilyocoris cimicoides*.



FIG. 319.—*Ambrysus signoretii*.

wrinkled, and sometimes obscured by two brown spots. The scutellum is livid brown, closely, minutely punctate, pale ochreous each side and at tip. The corium, membrane, and clavus are livid brown; the former closely, minutely punctate, shagreened, widely depressed, expanded, and pale on the costal base, with an uneven ochreous, transversely protracted spot next behind this, and a similarly colored, forked apical margin; the clavus is likewise punctate, margined all around, and with a spot at base, a squarish one on the middle and a slender line of ochreous on the submarginal suture. On the raised submargin each side of the prosternum there is an oval dark spot. The tips of all the tarsi are piceous. It measures half an inch in length, and fully one-third of an inch across the expanded part of the wing-covers. In the best watered parts of Arizona, and in Mexico, this fine species dwells in the quiet waters adjacent to streams, and in standing pools, especially such as are grassy. The colors here given are derived from specimens preserved in spirits. All these creatures are more or less greenish when alive, and the darker markings then appear blackish, or very dark olive brown.

Other representatives of the genus live in similar waters in California, New Mexico, and Texas, and a close ally of the foregoing inhabits ponds in Dakota.

The group is represented in America, Europe, Asia, and Africa by twelve or more genera, and about fifty species. A single form only, *Naucoris exclamatoris*, has thus far been found in Japan.

A neat passage to the land-inhabiting Heteroptera is made by the concluding genus of this family, *Aphelocheirus*. It is composed of the single European species *A. astivalis*, an insect which, with the general features of this family, has the elongated rostrum as in *Pelagonius*. Here the labrum still retains the free lid-like form, but is narrowed to the width of the rostral base; the antennae are likewise seated beneath the eyes, yet they are lengthened and extend well out beneath the pronotum.

The species is very broadly ovate, flat, and thin, with the head longer than wide, although deep seated in the pronotum. As seen in collections, it is a piceous brown insect, with nearly all of the upper surface minutely scabrous and punctate, the head, rostrum, legs, margin of the pronotum, and a large spot next each shoulder, margins of the abdomen, and a few spots on its disc, and the posterior margin of the short wing-covers pale yellow. The end of its abdomen appears ragged by reason of the deep-cut incisures of the three last segments. It measures about one-third of an inch in length, and dwells among the aquatic plants in brooks, ponds, and wells in England, France, and southern Germany. It is of great interest from the peculiar manner in which the wing-covers are shortened in its most common form. These are simply short and wide leathery plaques, which fit down into a corresponding depression of the meso- and meta-thorax, overlapping a little the base of the abdomen, and projecting sideways into an acute angle as if to compose a basal abdominal segment. In the winged form, however, the membrane is complete, the connexivum is widely uncovered, and the base of the corium covers very nearly the width of the abdomen. Here, too, the outer angles of the ventral segments are much more prolonged into tooth-like processes. The fore-tarsi are also furnished with two claws of different length, as on the other feet.

Having now passed through all the groups of the essentially aquatic Heteroptera, we reach the grand division AUROCORISA, so named from the fact that all the forms live in the open air, instead of beneath it in the water. It is true, however, that cer-

tain groups, such as the Hydrobatidæ, Veliidæ, and Hydrometridæ, are to some extent aquatic, but their motions are chiefly directed upon the surface of the water, into which they never plunge, except from urgent necessity, and in which they are not able to survive for any considerable length of time. These are all truly aerial insects, and take their food upon either the surface of the mud, the water, the land, or above it in the trees. First among the former of these we find the GALGULIDÆ. This family is composed of dark brown or blackish insects which pass their lives on the muddy margins of streams, or about the outer parts of marshes, where the soil is moist but not continuously submerged. They are short, clumsy-looking insects, with a thicker body than any of the foregoing, with a nearly vertical, shield-like, triangular face, eyes bean-shaped and prominent like those of a crab, the rostrum short, stout, acute, directed horizontally backward; a prothorax knobby and humped above the level of the short, blunt wing-covers; stout, spinous, short fore-thighs, surmounted by cruel, thorny, bent shanks, terminated by a pair of long, sharp nails. The hind-legs are much longer than the others, spinous, and attached to round, rotating coxæ, which gives them great freedom of motion. One exception to these general statements occurs in the genus *Pelagonus*. It is not of the gloomy mud color which we have cited, but is more or less tinged with bluish on a clearer dark-olive ground, marked with orange on thorax and sides of abdomen, and is destitute of the asperities so conspicuous upon the upper surface of the other genera. The fore-legs are also slender and fitted for running; not calculated for seizing and holding prey as in *Galgulus* and *Mouonyx*. The rostrum is, however, a dreadful instrument, sharp as the finest needle, extremely thick and stout at base, and a deadly probe to the poor larva of horse-fly or other insect which lives next the surface of the ground in situations near water.

The genus consists of but few species. One inhabits Europe, and is distributed from France into Africa, and thence as far south as to the Cape of Good Hope. Thus far seven species have been discovered. Of these, four came from Asia, one from Central America, one from Europe, and one from the United States and West Indies. The color of all these species is much the same, that is, a velvety bluish, or black tinged with blue, more olivaceous beneath, with a spot of bright yellow on each lateral margin of the prothorax, and a series of spots of the same color either on the connexivum, or on the outer margin of the wing-covers. They all have a pair of minute ocelli between the eyes; and the antennæ, although attached beneath the eyes, are not let into a hollow, but stand out free and exposed. These organs are also slender and composed of long joints.

Our native species, *P. americanus*, is a velvety blue, black beneath, marbled with deep black above and sprinkled with golden yellow points; the face is coal black, and the rostrum piceous. Each side of the prothorax, behind the front angles, there is a bright yellow spot of variable size; the prothorax is transverse, but a little narrower than the abdomen, and the lateral margins are depressed and thin, on the costal margin of the corium five not very distinct yellow spots appear. The legs are slender, dull yellow, tinged with piceous, and the knees, tips of the shanks, and ends of the tarsi are pitch brown. This is a gay, active little insect, which measures only one-fourth of an inch in length, and lives among the grass and weeds on the margins of brooks and ponds from Massachusetts to Texas. It is also not uncommon in the island of Cuba. It differs from the very similar European species in being narrow in front, and in lacking the spots on the underside of the connexivum.

Galgulus is a heavier built form, with great, prominent eyes, which are hollowed out beneath to receive the short, stout antennae. This is succeeded by an expanded plate on the margin of the prothorax which fits intimately against the eyes when the head is set back, and forms an exquisite contrivance for shutting in and protecting the antennae when the insect burrows into the sandy muck of its home, and also when caught by the freshets which drive the grit-loaded water over such spots.

Our *Galgulus oculatus* is a variously tinted chunk of insect entity, thick in front, horizontal, and gradually thinning towards the bluntly curved posterior end of the abdomen. The form thus resembles an Indian hoe or stone skin-dresser. The sides of the prothorax are expanded into thin, bent lobes, before which the margin is deeply sinuated, and then rises into the smaller, hollowed lobes which fit against the eyes. These lobes are ivory-white beneath, and next them the pleural depression is covered by fine, dense, pale granules on a dark spot. The upper surface is mud-brown of any shade, or it is red if the creature lives in a soil charged with oxide of iron, or blackish brown in carbonaceous mud, or clear light brown if developed in clean, sandy loam, or flecked with silvery white on a mottled and variegated more or less olive greenish ground, when its birthplace and home are in the micaceous mixed soil. Almost the entire upper surface is closely set with fine, raised granules, which give it a velvety appearance in some lights. Occasionally it frequents places where green slime accumulates between the stones near the bed of a brook, and then it is apt to be covered, and even permanently penetrated by the bright green color of the algae. The legs are pale yellow, banded with brown; the stout, compressed fore-thighs are generally brown, interrupted by short, yellowish, transverse marks, the underside armed with marginal, close-set, piceous, short teeth, separated by a longitudinal groove into which the spinous, bent, banded, fore-tibiae fit. The latter are also armed with a bunch of long spines a little way from the base, and between the others there are numerous more slender, shorter ones, which are continued upon the tarsi. The apical tarsal joint is also finished by a pair of long, curved nails. The other femora and shanks are likewise banded with pale brown, and have a pair of long, piceous curved nails. These organs are especially adapted to their predacious, carnivorous habits. They may often be seen in the month of May walking about between the stones on the low banks of brooks and streams, where *Tettie* and *Batrachidea* abound, watching an opportunity to seize one of these insects, and when the favorable moment arrives, leaping suddenly upon one of them, clasping it with tight embrace between the front femora and tibiae, and there sucking out all its vital juices.

It leaps with extraordinary facility, and in this way often eludes its pursuers by alighting on spots which almost exactly match its colors. Prof. Cyrus Thomas informs us that in southern Illinois it leaps in pursuit of *Xya terminidis*, which it captures in this way. It is, however, far from showing a preference for small Orthoptera, but seizes with apparently little discrimination the larvæ of ground beetles and almost any other kinds of insects which come in its way. It is distributed from Lower Canada throughout all of the eastern United States, westward to Vancouver's Island, and south to Lower California, Mexico, Central America, and through South America to Rio in Brazil. In the last-named country other species of different forms occur, but our species lives there with precisely the same figure, and presents many of the identical varieties that we observe in our own land. A second brood sometimes appears in August,



FIG. 320.—*Galgulus oculatus*.

throughout the Atlantic States. The genus is exclusively American, and several nominal species have been made upon characters which seem too evanescent for substantial separation. But since we now know them to vary here in harmony with the soil upon which they live, as well as with reference to their condition of vigor and maturity, we may safely infer that similar modifications will affect them and change their colors and markings in the other countries where they dwell.

Next akin to *Galgulus* is the old genus *Mononyx*, which Dr. Stål has erected into a sub-family, embracing five so-called genera. The genus *Mononyx*, as now restricted, comprehends most of the American forms, and a single species from New Guinea, which has a wider thorax than is normal to the group. These insects are all rough and uneven on the upper surface, almost cut square off in front, bluntly rounded, behind, almost flat, of a mud brown or blackish color, and fore-legs fitted, as in the preceding genus, for seizing and holding insect prey.

One species inhabits the United States, being found in Georgia, Florida, and Texas, the *M. stygius*. It is a most unattractive species, dark brown, or pale brown, obscured by darker on the discs of the prothorax and wing-covers, hispid and tuberculated upon the uneven prothorax, with its sides and the base of the costal area of the corium flattened, expanded, and thin. The legs are dull yellowish, darker on the shanks and tarsi, and with picaceous spines and nails. The anterior femora are very short, broad, and flat, triangularly produced below, and on the lower side closely armed with short, fine teeth; the two posterior pairs of femora are crossed by two pale brown bands, and the knees are also obscured. A less prominent dilatation of the front angle of the prothorax than in *Galgulus* is here scooped out to cover the antennæ in conjunction with the excavated base of the eyes, but in this it does not seem to form such a close cover beneath. The vertex slopes forwards, and is terminated on a ridge by two short processes placed upon the middle, the front is thus carried beneath and the rostrum is bent back against the sternum, as in some Homoptera. Here the eyes are not nearly so prominent as in the preceding genus, the head is much narrower, and the ocelli are disguised by the inequalities and roughness of the surface.

This species is one of the smaller members of the group, and commonly measures a little more than one-fourth of an inch in length, by two full lines in width. Very little has been reported respecting the habits of these insects; we only know that they frequent damp ground near water, and that they seize their prey by using the raptorial fore-legs, which constitute a lever by the movement of the shank against the knife-like, armed expansion of the femur. The nail which constitutes the end of the fore-tarsal joint is sharp and curved.

Probably the most monstrous form of the group is the large and broad *M. amplicornis*, which inhabits eastern Peru and the region watered by the Orinoco River. It is of a dull mud-brown, with the great broad prothorax spread out sideways like wings. Its head, prothorax, and scutellum are humped, ridged, uneven, and roughly punctate, and the head strongly suggests that of a cicada, both in form and direction. Its fore-legs are correspondingly thick and powerful, and strongly suggests the energy which it might employ in conquering its victims.

All of the foregoing are fully winged, with complete and ample membrane, which widely overlaps the tip.

Various other, in general more simply constructed, species inhabit Mexico, Central America, and the tropics of South America; all are inhabitants of warm regions, and

the group is entirely unrepresented in Europe. Sub-genera differing from the above in the form and proportions of the ridges upon the sternum, and in the appendages to the wing-covers, inhabit Australia, some of the islands of the Pacific Ocean, and Africa. In two of these, *Matinus* and *Scytellus*, the membrane is much narrowed, and confined to the border of the corium.

From the foregoing to the more comprehensive family, SALDIDÆ, is but an easy step. Here we meet with a decided advance in the plan of structure, although some of its elements still cling to the pattern which we have just left. *Pelagonus* has prepared us to look for particulars of form suited to a more essentially terrestrial mode of life. In the present family we have types which, like *Galgulus*, make holes for themselves, and live for a part of the time beneath the ground. Like the members of that genus, too, a majority of these inhabit damp soils, and are often found in countless numbers upon the salt and brackish marshes of our sea coasts. Their manners strongly recall those of the tiger-beetles which inhabit the same places. When approached, or in any way disturbed, they leap from the ground, arise a few feet into the air by means of their wings, and alight a short distance away, taking care also to slip quickly into the shade of some projecting tuft of grass or clod where the soil agrees with the color of their bodies. In this family we observe insects of small size, generally having a black, brown, or drab-colored body, with white or yellow markings. Here the head is no longer crowded back into the thorax, but stands out free on a cylindrical base, with large and prominent eyes, still retaining a certain proportion of the sinus which in the foregoing serves to enclose the antennæ. In these the antennæ are long, unconfined, and placed well down on the sides of the cheeks, and composed of four joints, of which the basal one is short, thick, and somewhat curved, while the second is very long. The rostrum is very long, thick at base, with a short, narrow tylus, wider labrum, and extremely lengthened third joint, succeeding which the fourth tapers off to an exceedingly acute point. On the crown of the head a pair of ocelli are placed close together like twin gems. The prothorax is either subulate or trapezoidal, and transverse, when the angles are more defined. The scutellum is large, long, and acute; and the wing-covers are complete, with a membrane usually narrowing towards the tip, and charged with long, narrow cells. The legs are long, having somewhat compressed thighs, of which the two hind pairs have spines on the knees; the shanks are long, slender, armed with remote, stiff bristles, and with a circle of spines on the longer hind pair, serving to aid the creature in starting to leap, and the tarsi are long, three-jointed, and furnished at tip with a pair of slender, curved nails. Some of the forms are very broadly oval, but the greater number are elliptical or long oval, with the outline disturbed by the prominent eyes.

America is the principal dwelling-place of these remarkable insects, and in North America especially may be found the greatest variety of species, and the most attractive designs of ornamentation. Every considerable sea-beach from Cape Cod to the Florida reefs presents some local form or variety of this type, and on the marshy spots of the sea islands, droves of them may be frightened up as the explorer passes from one bare spot to another.

The most elegant species known, *Saldid signoretii*, is one which is distributed over the pale sand-beaches of Provincetown, and from thence to the deserts of Sonora, Mexico, and which attains its full size and beauty of ornamentation upon the low levels of the plains of Cuba. In the United States, however, upon the paler-colored, but damp sea-beaches, especially near drains and marshes, and on the alkaline deserts

of the west, as well as in the vicinity of salt springs and lakes, this species abounds, presents numerous patterns of marking, and various depths and degrees of coloration,



FIG. 321. — *Saldia signoretii*.

in agreement with the kind of soil upon which it lives. It is of a somewhat longer form than most of the other native species, with the face, antennæ, legs, breast, sides of the pronotum, two spots next the tip of scutellum, and the exterior length of the corium ivory white. In one variety this white color invades the upper surface more or less extensively, and sometimes covers the greater part of the head, prothorax, and wing-covers. In another, this color is restricted to the margins and a few small spots on the corium; so that the insect appears mostly black.

One of the ordinary varieties has the crown of the head, excepting two pale dots behind, the disk of the prothorax and a round spot on each humeral angle, the scutellum, excepting two spots at tip, the corium and three spots on the costal areole, most of the venter and sternum, and a band across the base of the anterior coxæ, black. The antennæ are more or less obscured on the upper side, while the knees, tips, and spines of the two posterior pairs of shanks, with the tips and incisures of the tarsi and the nails, are black. All but the base of the rostrum is dark piceous. It is rather more than one-fourth of an inch in length, by one-eighth of an inch in width. It is a very active little insect, which may be observed on the sandy beaches of Maryland, running swiftly over the damp surface left by the tide, searching for food, and thrusting its rostrum into drowned flies and other insects, in company with *Cicindela dorsalis*, whose wary motions and sudden flight for short distances it imitates. It is, however, not confined to these outer beaches, but may also be found upon the darker sands and peaty marshes farther inland, where its colors become darker, in agreement with the soil.

Like some *Cicindela* and other insects which tenant these black, boggy surfaces, it sometimes becomes suffused with black, obscuring the markings and hiding its true colors; but much of this black pigment is temporary, and may be washed out by baths of dilute alcohol.

Multitudes of other species inhabit different parts of the United States, and one large, black species is found as far north as Great Bear Lake, and near the Yukon River in Alaska. Some of the smaller species, with black ground-color, marked with white, are distributed over the greater part of North America, being found near streams of water, or about the drier parts of fresh-water marshes. A group of pale horn-colored species, with hairy surfaces, inhabit the marshes of eastern New England and of Illinois. The shores of the Great Lakes are tenanted by other forms, which are often caught by driving storms and piled upon the low beaches at the edge of the tide.

In Europe, numerous species occur in almost every country from the north of Scandinavia and Scotland to the borders of the Mediterranean; but, strange to relate, no forms have thus far been reported from Africa, Australia, the islands of the Pacific Ocean, or the East Indies. On the western hemisphere, on the contrary, they are well represented in most of the large countries, as well as in Central America and the West Indies.

The preceding forms have generally been referred to a single genus; but in France and Algeria a more elongated type, *Leptopus*, occurs, in which the prothorax is con-

tracted anteriorly into a neck, the antennæ are mere threads, and the upper surface is often spinous. These are strongly suggestive of certain tropical forms of Reduvids, which they also resemble in the thickened fore-thighs and pattern of coloration.

Leaving these tenants of the damp soils, we are at once brought into the presence of several families of the Heteroptera, whose habits agree in many particulars, but whose forms are as diverse as their representatives in the perfectly terrestrial groups. These all coincide in living upon the surface of the water, yet, not submerged beneath it, as in the aquatic insects previously considered.

The first family, HYDROBATIDÆ, includes insects built upon an elongated pattern, with prominent round eyes, the head inserted in the thorax up to the base of the eyes, and curving forward, from which the stout rostrum bends back to pass between the fore-limbs. Long antennæ, of four joints, arise from the prominences, placed some distance in front of the eyes, and the back part of the vertex is depressed. No ocelli are conspicuous, if indeed they are present. The thorax usually widens backwards, and its thickness is increased by the prominent middle and posterior coxæ, which project beyond the sides. No scutellum is apparent, but in its place the end of the dorsal plate of the mesothorax is scale-like, narrowed, rounded, and depressed around the tip. Behind this the abdomen tapers more or less towards the last segment, which is usually armed each side with a tooth-like process. The under side of the body is generally minutely pubescent and sericeous like satin, and this is sometimes continued along the sides of the thorax. There are commonly two forms of the adult belonging to the same species, the winged and unwinged. These do not necessarily coexist. During some years only the winged forms appear, while in others, and especially if the spring and summer are cool, the individuals will all be unwinged. Often in sunny, protected places, where the food is abundant, all will be winged, while in exposed localities the same species will be found unwinged, with perchance a single, more vigorous specimen winged. In some parts of the Southern States three forms occur, those before cited and another which has the wing-covers of scarcely half length, but with these organs as nicely differentiated into corium and membrane as the most completely developed.

The old name, *Gerris*, by which many of these insects were formerly known, has become obsolete, by reason of its having been used for various insects not generically connected, so that recently Dr. Stål has been obliged to remodel the family, construct several genera, and place the assemblages of species in newly defined relations. Thus our most common species, *G. remigis*, has been taken from *Gerris* and is now placed in the genus *Hygrotrechus*. It is a rather large, dark brown, moderately stout species, with the crown of the head, prothorax, and callosities at its end blackish; the antennæ are black, and about as long as the distance from in front of the eyes to the tip of the dorsal piece of the mesothorax; the first is longer than the next two conjoined; the second and third are short, of nearly equal length, and the fourth is longer than the third. An ochreous line, ending in a hollow space behind, runs along the middle of the prothorax; the dorsal segment behind this is a little sinuated each side, has a feebly raised, uneven line along the middle, slightly raised lateral edges, and a callous, waved, black seam immediately outside of its lateral margin and running diagonally



FIG. 322. — *Hygrotrechus remigis*.

backwards. The bucculae, antepectus, and base of the two posterior pairs of coxae are pale ochreous; the corresponding thighs and shanks are dark tan-color. A narrow stripe, composed of gray streaks, interrupted by black dots, extends along the middle of the tergum; and the outer edges of the connexivum are tan-brown, raised and marked with a sericeous spot in the angle of each incisure. The terminal segments are usually also tan-brown. In fresh specimens, the whole upper surface is invested with minute, bronze pubescence, and the sericeous plush is continued in an interrupted stripe on the upper side of the two posterior pairs of coxae. The processes which terminate the abdomen are acute, and extend to about the tip of the first genital segment, while the sides of the last abdominal segments are a little waved in the female, but oblique in the male, and deeply concave on the middle. The species measures a half-inch, or rather more, to the end of the venter. This, like many of its congeners, is an excessively active and conspicuous insect on all our brooks and streams of water. It moves rapidly by rowing with the long, slender, and hairy hind legs, and is generally seen in small groups on the quiet parts of the waters. The depth of color and degree of wrinkling of the back of the mesothorax depend much upon the maturity and vigor of the individuals; the heavier and coarser ones, being the stronger, have a thicker integument, while the more delicate preserve the paler colors, and often clearer markings.

These insects stow themselves away under the banks of streams, in the mud beneath leaves or rubbish, or at the bottom of water under stones and roots of trees when the autumn begins to be cold, and from thence they reappear upon the surface of the water as soon as the warm weather of spring returns. Soon after this the eggs are attached by a sort of glue to the leaves and stems of aquatic plants. They are whitish translucent, long, cylindrical, more blunt at the end from which the young emerges than at the somewhat tapering, but round, opposite extremity. If the weather continues to grow warmer, these eggs mature in about two weeks; then the larvæ push their way out, not, as in many other Heteroptera, by thrusting up the lid, but by bursting through a slit which opens a little way down the side. Numerous other species inhabit this country, and resemble those of Europe in the general plainness of their brown suits and slight ornamentation; but in the East Indies the forms are often bright yellow, and adorned with dark marks and stripes.

Our smaller species, which are common on the pools, ponds, and water in swamps and ditches, have mostly a dark, fuscous or blackish-olive ground color, bordered with yellow on the sides of the abdomen, and belong to the genus *Limnotrechus*. These have the carinate line on the dorsum of the thorax very distinct and unbroken. Some of these latter have a wide distribution, being found far north on the waters of Great Bear Lake, and from thence extending southward to New Mexico and Texas. On the eastern side of the continent *L. marginatus* may be found from Maine to Georgia. A very pretty, highly polished, black species, margined and striped above with yellow, but pale yellowish beneath, and with pale, fulvous legs, the *Limnometra marginata*, inhabits southern Florida, the Antilles, and eastern Peru. It lives on the quiet parts of the streams in Cuba and San Domingo, and is closely related to one or two species inhabiting the Philippine Islands. About fifty species belonging to this part of the family have already been discovered, of which the greater number thus far described have been captured in Europe and Asia. The American forms have been much neglected, and scarcely more than half a dozen have been recorded as from the United States.

A series of genera, represented by *Brachynotus* from Brazil, and *Metrocoris* from Ceylon, effects a fine transition from the preceding forms to the assemblage of genera formerly placed in the old genus *Halobates*. Most of the species belonging to the latter are remarkable for being residents of the warm and more quiet parts of the surface of the great oceans of both hemispheres. It is therefore in the region of calms near the equator, and amidst the great tracts of Sargassum which float there, that these creatures are most at home and appear in the greatest numbers. As the patches of this sea-weed are sometimes widely distributed by the storms and currents, we occasionally meet with them at long distances from their original locality, and this may account for the sporadic examples of the *Halobates*, which are occasionally found in the Atlantic Ocean as far north as the coast of North Carolina. These insects are truly pelagic, living at distances of many hundreds of miles from the nearest land. But as they must find some object in the water suitable for the attachment of the eggs, the floating sea-weed becomes at once available, and furnishes a nidus similar to that which their brethren of the fresh water discover in their native streams on the mainland. Eleven species of the genus as now restricted have been taken in the Atlantic, Pacific, and Indian Oceans. Of these, the greater number belong to the eastern hemisphere, and only one, *H. strepitans*, is said to be restricted to the Atlantic Ocean. Doubtless the storms of these oceans, and the tremendous currents which course along the coasts of the continents, have carried these insects far from the places where they originated, so that, as we now find, the larger proportion of the species inhabit both of the great seas, instead of being confined to restricted areas of either.

The most representative form is perhaps the *H. swellerstorffi*. It is of a lead-gray color, plump, oval form, paler on the sides and below, and with two orange spots on the base of the head. The black eyes stand out like round beads, the legs are steel-blue; the middle pair are larger and stouter than the hind ones; the fore-tibiae have a stout tooth beneath, near the tip, and the hind tarsi are one-jointed. Specimens of the male show a longer and somewhat narrower body than the female, while the genital segment is large, conspicuous, almost bulb-like. This species, when full-grown, measures about four and a quarter millimetres in length, but specimens as commonly seen in the collections are much smaller in size, owing to their being undeveloped. It is a common form near the coast of Lower California, and not less so at Key West, Florida, and along the borders of Cuba and Saint Thomas. Numerous specimens have also been found in the Atlantic Ocean, from latitude 43° north to 20° south of the equator. Other localities have also yielded specimens, as, for example, the east coast of Africa, Sunda Straits, and vicinity of Norfolk Island.

Quite in contrast with the foregoing is the genus *Halobates*, which differs in having the body longer and narrower; the eyes less prominent, deeper seated, the fore-tibiae with a nearly straight process at the tip, and the hind-tarsus two-jointed. Instead of being lead-color or some shade of gray, the colors in this genus are yellow, marked and striped with black. Four species have already been made known, all of which came from the seas of Asia. The best known, *H. lituratus*, is from Japan, and measures nearly one-fourth of an inch in length; another, somewhat larger, lives in the ocean near Ceylon. All are said to be unwinged. Two genera of great interest inhabit the United States and West Indies. Mexico shares in the first



FIG. 323. — *Halobates pictus*.

to be mentioned, but appears to lack the other. One of these is based upon the *Halobates pictus*, but has been described as a new genus, *Stephania*. This sprightly little insect lives in gay assemblages of many individuals upon the more quiet surfaces of our eastern streams, from Massachusetts to Florida, occurring also in Cuba and near Tamaulipas, Mexico. It is of a yellow color, with a black stripe on the head, which is either interrupted or runs down to near the base of the rostrum; the rostrum is piceous, interrupted by yellow near the base; on the prothorax two black lines along the middle spread apart behind; a similar line occupies each side, and is continued unevenly back to the end of the mesothorax; on the latter a line runs down the middle with a dot on each side; and exterior to these the lateral, wider lines run backward and curve inwardly until nearly meeting on the middle of the posterior margin. Most of the sutures on the abdomen, pectus, and flanks are black, and black lines extend along the sides of all the legs. Many varieties occur in which the black color invades more or less of the surface, particularly of the upper side, so that some appear black, marked with a few yellow stripes and spots.

If this genus is to be accepted, the characters presented by the thorax and wings cannot be overlooked. In the unwinged state, although capable of laying eggs and continuing the species, these insects fail to acquire their full plan of structure, and there is consequently an arrest in the formation of the thorax. In this complete form the wing-covers are elongate-obovate, smoke-brown; the coriaceous part rather less than half as long as the membrane, narrowly tapering towards the base, furnished with three stout veins, the outer and inner of which run nearly parallel to the margin, while the third extends along the middle, and ends in a small cell; the boundary between the two portions is made by a coarse transverse vein, and the base of the costal margin is quite pubescent. The membrane has the outer and inner submarginal veins of the corium continued through it to the tip, where the two unite in a loop; the middle one is continued to the very tip, in the form of a suture, and is paler than the adjoining surface. The wings are also brown, opaque, much shorter and narrower than the wing-covers, with three long veins reaching to the tip, and a basal one curving towards the hind margin. Here also the pronotum occupies the whole width of the dorsum, lacks the suture which divides it from the mesothorax, and the two united are free, forming a cap over the other segments of the mesothorax, and behind them two transverse callosities, possibly the dorsal pieces of the metathorax, spread across the base of the wide first abdominal segment.

Thousands of these insects appear upon our streams of water every year, and I have searched diligently to secure other winged specimens, but this single female, which occurred to me while examining a group of them one very hot, but damp, eighth of July, is the only one that has ever been found, and so leaves the history of one sex still shrouded in mystery. Nor are we so well off in the genus *Halobates*, for notwithstanding that they have been collected at various times of the year, in many of the warm parts of the oceans, not a single winged specimen has been reported by any scientific observer.

It seems unlikely that wings could be of much use to creatures whose home is on waters so distant from the varying conditions of the mainland; but as we know that some of these species, as, for example, the *H. wuellerstorffii*, approaches our southern coasts, and from such places might have had its original distribution, it seems quite likely that winged forms of this, if not all of the species, will yet repay the collector who visits their places of refuge at the proper time of the year.

One more form deserves especial mention at this point, the *Metrobates hesperius*, a native of our eastern and southern States, as well as of the Antilles. It is a merry, active little insect, more plump and broad than the foregoing, of a dull, velvety blue-black or dark brown color, marked on the base of the head and fore part of the prothorax with dull yellow, the second spot being sometimes tinged with bluish-gray; the eyes are prominent and hemispherical in the unwinged adult, and it also has the prothorax narrow, somewhat like a neck, but in the winged state the prothorax caps over the base of the head between the eyes, and is only faintly marked off from the broad mesothoracic scale by a feeble sinuated suture. All the upper surface of the body is more or less velvety pubescent; the dorsal scale is bluntly rounded at tip, and feebly sinuated each side; while the wing-covers, when at rest, are narrower than the thorax, gradually decrease in width towards the tip, project far beyond the end of the venter, have a thick corium with two elongated cells, bounded by stout veins, and a membrane more than twice as long as the latter, which has a stout vein running parallel to the inner and outer margins, and continuing around the apex as a loop, and along the middle the vein-like line forms a suture throughout the whole length of the membrane. The antennae are thick, the basal joint curved, slender at the inner end, longer than the three others conjoined, acuminate at tip exteriorly; the second and third short, abruptly thickened at tip. The posterior tarsi are one-jointed, slender; and the nails of the stout anterior tarsi are placed about one-third of the length from the tip.

This species is larger and stouter than the preceding, and, when full grown, measures about one-fifth of an inch to the end of the abdomen. Like the *Stephania*, it moves very rapidly over the surface of the water by rowing with its long middle legs, and has the same habit of jumping from the water to grasp mosquitoes, flies, and other insects. Both of these insects imitate the larger *Limnotrechus*, etc., by diving beneath the surface when frightened or pursued. The eggs are attached to the projecting twigs, leaves, and stems of water-plants during early summer, and by the middle of that season countless multitudes of the young may be seen in company with the adults on the bayed-out, quiet parts of our inland streams. No winged specimens have yet been found in the United States, but in the Island of San Domingo both forms live in company on the surface of the rivers.

A closely related family, VELIDÆ, occupies the next place, and is composed of insects having a form combining to some degree the characters of the foregoing group and those of the more advanced Hemiptera. Here the body is short and deep, with shorter limbs, mostly adapted for running over the water, rather than for rowing. Like the preceding, they pass most of their time upon the surface of the water, but always near the banks of the stream or pond, but they also make excursions beyond the limits of the water, and move with great freedom upon the land. The head is set closely into the prothorax, with the eyes round, projecting a little each side, and the face either short, convex, or produced into a thick, blunt cone. A three-jointed rostrum, recalling that of *Saba*, but thicker, extends horizontally backwards to beyond the fore-coxae, the second joint of which is longer than all the others united. The antennae are four-jointed, either short and quite stout, or having one or two basal joints thick, and the following ones very slender. The prothorax and mesothoracic cover are scarcely separated; the latter is free and more or less protracted backwards, either blunt or triangular. In some genera the two pairs of hind tarsi are split; in others they are entire, and the curved nails are placed next the tip. The number

of tarsal joints is variable, some having two, others three joints; a few genera have only one to the fore-tarsi. This group is composed of mostly small, or even minute insects, the longest of which do not exceed one-third of an inch in length.

A common North American form is the *Rhagovelia obesa*. As a genus, it is distinguished from *Velia* by the blunt forehead, and by the apical tarsal joint of the middle feet, which last is slender, spindle-shaped, split to next the base, and at that point the slender claws are attached. It is of a bronze-black color, with the upper part of the abdomen and legs highly polished, the latter metallic green, and the hind thighs of the male much thicker than those of the female, armed beneath with a series of sharp teeth, the innermost one forming a longer spur; the middle tibiae are nearly cylindrical, a little tapering at tip, and armed on the inner side with close-set, very short teeth. The abdomen of the female appears pinched behind, so that the lateral ridges are brought in contact on the middle line. The base of the antennae, two oval spots on the front sub-margin of the prothorax, coxae, and hind margin of the middle and posterior acetabular caps are pale yellow. The rostrum is piceous, paler at base, reaches to the middle coxae, and is very acute. All over the upper surface of the winged form a fine brown pubescence is conspicuous, which is much less observable in the unwinged, and easily rubs off. A beautiful, silky, white sheen decorates the pale blue color of the venter in both states. The wing-covers are dark brown, gradually widening towards the tip; the corium grades into the membrane, and the discoidal cell is angular, and connected at each end with another angular cell, bounded by stout veins. These wing-covers are sharply bounded by, and set between, the carinately raised connexiva, which are often of a bright orange color. Both sexes of the winged form have a carinate line on the middle of the mesothorax, and this in the female is produced into a slender process, which has a blunt fork at the tip. The end of the last abdominal segment is acutely produced in the winged specimens, but much less so in the unwinged ones.

This plain colored but interesting species inhabits the eastern side of the continent from Lower Canada to southern Florida, and westward into Texas. In the Middle States it has not yet been found winged, but in eastern Tennessee, North Carolina, South Carolina, and Florida the winged form is common in company with the unwinged. They walk over the water with the greatest facility, and often use the longer middle legs like oars, with somewhat of a rowing motion. It is interesting to observe them on the quiet surfaces of the creeks and branches, where they love to remain in groups, staying together motionless for hours at a time, and then gliding away in all directions when startled by the approach of some disturbing object. *Rhagovelia* is confined to the new world, and several larger species than the foregoing inhabit the West Indies, Mexico, Central America, and Brazil.

Next to these comes the genus *Velia*, which is represented by several species in South America and Mexico, and by two others in Europe. In this genus the forehead is produced forwards, somewhat in the shape of a blunt cone; the antennae are longer and more slender than in the preceding, and the two apical joints are long, much more slender than the others, and the third joint is longer than either the second or fourth. The first joint of the fore-tarsi is quite short, while the two posterior tarsi are long, with cylindrical joints, and the nails are placed on the tip. The mesonotal plate is long, triangular behind, and carried pretty far back over the base of the wing-covers. These last are also furnished with three cells along the middle, between the base and the tip, and the corium is tolerably well distinguished from the

longer membrane. The largest and best known species is the *V. rivulorum* of Europe. It is of a tan-brown color above, fulvous beneath, with the breast, head, and legs darker, and the wing-covers still darker brown, with four white dots across the base, another behind the middle, and still another near the tip. The thorax is roughly wrinkled, humped, and remotely punctate. It measures about one-third of an inch in length. This is an elegant looking insect, which is much decorated by the silvery white spots of the wing-covers, as also by the small white spots on the sides of the connexivum, flanked by the black ground of the tergum, and the black, triangular spots on the margin of the connexivum. It is widely distributed throughout Europe, being found in England, Germany, France, Spain, and Italy upon clear rivers and creeks, from early spring until cold weather in autumn. The unwinged form is stated to be the most common in England, and it is held by the Germans to be a distinct species, which they preserve under the name *V. currens*. This is quite out of analogy with the other forms of the group, in almost every country where species of this genus have been found.

A still more beautiful form is the velvety brownish-black *V. basalis*, which inhabits Brazil. It is a more compact form than the preceding, with a broad head, set more closely against the front of the prothorax, with still longer antennae, and the bases of the legs and a long spot on the origin of the wing-covers bright yellow. The rostrum is piceous, and extends to the base of the middle coxæ. It measures rather more than a quarter of an inch in length, and is of a deep boat-shaped figure. It lives on the waters in the vicinity of Rio, extends back into the interior of that country, and varies considerably in the size and colors of the spot on the base of the wing-covers.

A North American form, *Mesorelia*, with much longer head and somewhat spindle-shaped body, comes here. It constitutes another type of the water creepers which are widely distributed in the United States. Its head is wide and much prolonged before the eyes (as in the genus *Limnotrechus*); there is a distinct interval between them and the front margin of the prothorax, and a constriction across the extreme base. The antennae are very slender, filiform, longer than the abdomen; the basal joint is barely a little thicker than the others, of about the same length as the third and fourth, the second joint much shorter than the others, and the antenniferous tubercles are expanded in front so as to give a trumpet-like enlargement to the front of the cranium. From the slightly bent clypeus the slender rostrum extends back to the middle coxæ, the second joint being very long and tapering. The prothorax is contracted into a short, transverse front lobe, but widened at the shoulders, which are tubercle-like and prominent, and the posterior margin is cut almost square off; behind this the scutellum is conspicuous, and has a triangular, callous elevation on the disc and a smaller one behind it. A conspicuous pair of ocelli occupy the middle of the vertex, and are placed nearer to each other than to the eyes. The wing-covers are of thin texture, narrower than the space between the connexiva, have the corium long, furnished with thick long veins bounding the long and narrow cells, and the membrane with a single, short, straight vein running about half way back from the tip. A remarkably wide, membranous clavus occupies the entire length of the inner side of the corium and curves, while becoming more slender half way along the



FIG. 324. — *Mesorelia bisignata*.

margin of the membrane. The legs are moderately long, slender, with still more slender three-jointed tarsi, of which the basal joint is minute, and the second joint much the longest. Both pairs of posterior femora, besides the tibiae, are furnished with slender, short spines. The connexivum is wide, curved on the outside, and sharp-edged.

Our native species, the *M. bisignata*, is of a pale yellow color, with the gibbous hind lobe of the prothorax lead color, marked with a yellow stripe along the middle, the outer sides and tip of the scutellum, the veins and cuneus of the wing-covers, the eyes, the tylus, the apical joint, points of articulation, base, a few marks on the antennae, a large part of the end of the tarsi, and the tip of the tibiae are brown. It measures only a little more than one-tenth of an inch in length, and tapers to a rounded point behind. The unwinged individuals appear more slender than the winged ones, and often hibernate in this State. On the surface of the quiet waters which they inhabit, specimens may be seen at rest near the banks, or in the midst of the leaves of pond weeds. There they watch for the arrival of some hasty gnat or other small insect which chances to fall into the water. This they eagerly grasp with the fore-feet and proceed to suck its juices. Their movements are indescribably delicate and free. Nothing could be lighter than their motions over the surface, walking there without making impression or ripple, and moving with the celerity of a spider. Thus far it is known from Massachusetts and most of the States south of it, through Florida to Texas, and thence into Cuba and San Domingo. Its pale colors serve well to conceal it when resting between the leaves of *Potamogeton* or among other projecting objects upon the surface of the water, and it is only by stirring the surface in such places that its presence can readily be detected.

Two other species appear to belong to this genus, the original one first discovered in France, upon which it was founded, and another from the island of St. Vincent. Very near to this should be placed several more pigmies of the group, which deserve notice here as showing the kinds of differentiation which arise within its limits.

One of these is *Ilebrus*, which is represented in the United States by *I. americanus*. It is of an oval, somewhat boat-shaped, deep figure, with a nearly conical head, prominent eyes, antennae about as long as the abdomen, with the second joint a little shorter than the stouter, curved, basal one, the third and fourth more slender, longer than the basal joint, and both about equal in length. The membrane is long, has a discoidal areole of large size, bounded by coarse veins, and a space behind this separated by very slender veins. The prothorax is wide, triangular behind, constricted near the head, with prominent tumid shoulders. By reason of this segment being carried back the scutellum is hidden from view. A marked feature of this insect appears in the slender nails, which are placed a little way behind the tip of the tarsal joint, instead of at the end. The species is dark brown, and closely pubescent above, lead-colored and silky beneath, with the base and underside of the antennae, coxae, lower surface of the head, sides of the breast, lateral margins and tip of the venter, legs (excepting a dark stripe on the femora, the knees, and some clouds and spots on the tibiae and tarsi), the outer edges of the pronotum, and surface of the connexivum pale yellow or whitish. Just back of the head a narrow collar of orange-yellow crosses the apex of the prothorax. The outer edge of the connexivum, and also its transverse segmental sutures, are black, forming a strong relief upon the almost orange-colored ground. A somewhat variable element appears in the pale fuscous wing-covers, which, when perfectly fresh, exhibit about three whitish spots on the

discoidal areoles, but when rubbed these only remain in vestiges, or entirely disappear. It is a very small insect, measuring at most not more than one-tenth of an inch in length, but is a very attractive object when seen upon the surface of a quiet brook, where it runs over the surface with astonishing rapidity, not with the rowing impulses of a *Limnætrechus*, but standing well up and moving all the legs in steady succession. The unwinged ones are also rendered conspicuous by spots of white powder, which contrast strongly with the dark brown of the upper side of the abdomen. They hibernate in colonies beneath the overhanging banks of the little streams, in the Middle States, and by the latter part of June have undergone the last change of skin and become fully winged. A large proportion of them, however, do not enter the winged state, but pass through all their changes without gaining even a vestige of the organs of flight. Only in warm, sheltered situations do they pass to the full completion of the adult state, and in the colder parts of the country, as in Maine and Lower Canada, they seem to be always unwinged. Two species also inhabit Europe, and two or three others are natives of the West Indies and Mexico. A genus which might easily be confused with the preceding is *Microvelia*, which is known in many of the books as *Hydroëssa*. It is composed of very small insects much like the preceding, but the antennæ are thicker in the direction of the apex, have six joints, the third and fifth being very minute, and inserted between the longer ones, and there are no ocelli; the eyes are hemispherical, placed next to the pronotum; the rostrum reaches behind the fore-coxæ; the hemelytra are as long as the abdomen and have six consecutive areoles, of which the basal are smaller than the others, while the apical ones emit two nerves. All the legs are short and rather stout, unarmed, the fore-tarsi are two-jointed, the basal joint very short, the two hind pairs are three-jointed, with the third joint longest and thickest. The nails are situated a little way back of the tip on all the feet. Their general form is short, broad, and deep, with the margin of the connexivum prominently raised. *M. pygmaea* is a common form in many parts of Europe, and there are undescribed species in the United States and West Indies.

A strong contrast with the foregoing is seen in the family HYDROMETRIDÆ. It is composed of dull brown insects of remarkably elongated, almost linear, form, with long legs fitted for walking on the surface of the water. The species inhabit places where weeds and grasses grow in quiet waters, and there they delight to remain at rest, with perhaps a single claw hooked to some projecting object. When disturbed they move very slowly, and seem disposed to save themselves rather by concealment among rubbish or tangled growths than by active movements. The young forms are so very slender that they can only be detected with great difficulty in the places to which they resort. In the adult the head is long, horizontal, almost cylindrical, but with the middle a little narrowed, the tip widened, the basal tubercles of the antennæ projecting, and the round eyes placed about midway between the base and tip. The antennæ are mere filaments, with the tip of the basal joint enlarged, the second joint longer than the first, the third nearly three times as long as the second, and the fourth about one-half as long as the third. A short, very slender rostrum reaches to beyond the eyes, and has the base placed in a short channel. The thorax is almost cylindrical, a little wider than the tip of the head, but much shorter than the latter. No ocelli are present, and the legs are long, exceedingly slender, and with three-jointed tarsi, at the end of which the minute nails are placed. The wing-covers are narrow, gradually widening behind, generally shorter than the abdomen, bluntly rounded at tip, and furnished with two long nerves, which are connected behind the middle by an

oblique cross-nervule, and farther back by another, thus bounding an irregular cell. The long abdomen is rather flat above, but convex beneath, with the margins parallel in the male, and curved in the female.

Thus far only a single species, *H. lineata*, have been found in the United States. It is fuscous, with dusky hemelytra having fuscous veins; the wings are white, also veined with fuscous; the tergum is pale brown, and has the margins of the connexivum and the longitudinal sutures black, the transverse sutures are also often black, and there is a more or less distinct pale line down the middle. This species varies considerably in the depth of color and distinctness of the markings. It measures rather more than one-third of an inch in length, and closely resembles the *H. stagnorum* of Europe. Like the species just mentioned, it sometimes lives in the dirty pools, among the duckweeds, *Lemma*, where it wanders about over the green algæ and slime floating on the surface; the color of which it matches in the young stages.

Having considered the forms which live in the water, or which pass much of their time either on its surface or in the wet places adjacent to it, we reach those which are terrestrial or essentially aerial. None of these have the antennæ concealed, but always prominently standing forth from the sides of the head. These, with the sub-aquatic forms which we have just considered, compose the great section Gymnocerata of Fieber, just as the essentially aquatic assemblages belong to his preceding section Cryptocerata. This last group he also designates as a subsection, Aquatilia, from the genuine aquatic habits of the forms, while he places our marsh-loving genera in another subsection, Litoralia, and the terrestrial insects, yet to be considered, in a third subsection, which he calls GEODROMICA.

The first group of this largest of the sections is the superfamily Reduvioidæ. It comprehends a vast assemblage of forms, which are easily grouped around some central genus, forming in each case a natural family or subfamily, differing by easily recognized features from all the others. At least fourteen of these groups, embracing more than a thousand species, have already been made known. All the extremes of figure are found here, from the longest and most attenuated, to the flattest and widest.

All, however, agree in having a rostrum attached to the tip of the head, with the basal joint bent, causing the rest of this organ to curve beneath, the tip usually impinging upon the sternum and gliding upon a groove there. The eyes are prominent, hemispherical, lateral, and placed before the base of the head; when situated far back they are succeeded by a constriction resembling a neck.

Those which have an extremely slender body with thread-like middle and hind-legs, but with spinous, raptorial fore-legs, belong to the family EMESIDÆ. In the latter the eyes are placed generally about midway between the front and base of the head, and in a few genera, such as *Luteva*, *Orthunga*, and *Stenolemus*, are extravagantly large and predominant for such a small cranium. Several subfamilies have been founded within the limits of this group, upon characters of apparently minor value when taken in connection with the sum total of their structure. The first of these, called Emesida by Dr. Stål, is composed of species having only a single nail upon the fore-tarsus. It is represented best in the United States by a very long species, *Emesa longipes*. Its ground color is cinnamon-brown or fulvous, with the upper surface of the abdomen more or less reddish, pale stripes on each side of the head, a line also on the middle of the pronotum, and the margins of the hind-lobe also pale. The fore-thighs are indistinctly and partly banded with pale testaceous, the middle and hind-femora are twice banded near the tip with ivory white, and the shanks of the same

legs are pale, with a brown band beyond the knees. A very interesting element of structure is an adaptation of the interval between the fore-coxae for the reception of the tip of the rostrum. The space there is sunk into a shallow oblong pit, with the margins raised, and into this the point slides backward and forwards as the insect depresses or elevates its head. It measures about one inch and a third in total length, but with the great spider-like legs stretched out in walking appears fully twice that size. When lodged on the twig of a tree or bush it has a curious habit of swinging backwards and forwards like some of the long-legged spiders, such as *Phalangium*. This species is quite common in many parts of the United States east of the Rocky Mountains, from Massachusetts to Florida, and west to central Texas. In Maryland its principal home is in the young pine trees, where it may be seen with its two fore-legs placed close together and stretched out in front, as is the habit of our common phasmid, the *Diapheromera femorata*. Occasionally it leaves the trees and takes shelter in sheds, outhouses, and barns, where it may be seen overhead swinging by its long legs from a rafter or the lining of the roof. The immature form may be found roaming over the trees during early summer, but by the middle of August it acquires the organs of flight and becomes a fully developed adult. We do not yet know where it deposits the eggs: but from analogy we are led to believe that these are glued to the twigs of bushes and trees, just as is the case with many others of the great group to which this species belongs. The fore-legs are most formidable instruments in catching and securing the insects upon which it feeds: the long fore-coxae project far in front of the head, and furnish a swinging joint for the spined femora, which can be thrown forward like a flail, while at the same time the sharp tibiae are shut back against the acute spines, and the victim thus irretrievably transfixed.

Another sub-division of this family embraces species with shorter, wider heads, and forms which imitate the delicate and gossamer-winged gnats. One of these, *Ploiaria errabunda*, is the counterpart of an European species. It has a slightly flattened, long body, a bowl-shaped head with a transverse impressed line between the eyes, filamentous legs and antennae, and lichen-like markings on the filmy, whitish wing-covers. The ground color is pale or whitish, the prothorax obscurely brown each side, the corium pale brown with white veins, the end of the membrane has a smoke-colored spot, the surface before this is very pale-brownish, marked with white, and the legs and antennae are ringed with brown. It is one of the smallest of the group, and measures only one-sixth of an inch in total length. Its delicacy and small size have caused it to be a rare species in collections, but it is no doubt common enough upon the leaves and branches of the *Cornus florida*, where we have found it during the month of June.

Other species inhabit California, Texas, Mexico, and the West India Islands, some of which are even more frail and thin-winged than the foregoing.

The largest member of this sub-division is an extremely curious insect, built in the most intangible manner as far as the prothorax, antennae, and hind-legs are concerned. It is the type of the genus *Stenodemus*, and our species is *spiniventris*. Thus far it has been found only in Arizona, Mexico, and Cuba, but it will no doubt be seen to have a wider distribution when the hemipterous fauna of our southern states shall have been adequately searched out.

This anomalous insect may be recognized by the abruptly widened base and front of the prothorax, the latter part conforming to the width of the head, and the two together composing a club with a slender part behind, like a handle. The abdomen is narrower than the base of the thorax, but grows wider behind, and is covered, all

but the end, by the ample wing-covers, which are sinuated near the tip. Perfect specimens have a slender spine standing erect on the scutellum, and behind this a slender process which bends forwards; the venter has three pairs of spines along the middle, and a single series of shorter ones near the outer margin. The fore-thighs are long, moderately thick and armed beneath with close set, short, stiff bristles, and a row of remotely placed vertical spines, against which the shorter tibiae shut back. Only the male is here recorded, as the female has not yet been made known. Its color is pale clay yellow, marked with brown; the eyes, the transverse groove on the head, and the base of the rostrum are black. Brown bands cross the antennae, the femora and the tibiae, while the posterior femora are also streaked with brown. The prothorax is striped anteriorly with the same color, which also appears on the sternum of the narrow peduncle, and its sides are black. The abdomen is pale at base, but darker behind, and the anal segment is black, with a middle stripe and two lateral lines of a yellowish color. The wing-covers are milky-white, lichenated with brown of various shades. It measures half an inch in length to the end of the abdomen. The original came from Mexico, and it is possible that the other specimens distributed in the collections may prove to be distinct species, since they are more slender than the one here described, and lack the spines of the underside of the abdomen. The family as at present constituted contains about thirteen genera and forty species, from nearly all of the temperate and tropical parts of the world. Thus far the Orient and Europe have furnished the greater proportion of the species, so that the Emesid fauna of America seems very small in comparison.

We now pass to an allied sub-family, the Stenopodina, in which the head is still somewhat flat above and long, with the antennae attenuated towards the tip, but not filamentous, and which has tapering instead of thread-like coxae and legs. The hind pair is far longer than the others, but it is moderately stout. Here the body is elongated, but never linear, and the last segment of the body, particularly in the male, is depressed and foliaceous. The colors are generally tawny, marked with fuscous. A very large species of this group, *Stenopoda culiciformis*, inhabits the southern United States from North Carolina southward to Cuba and westward to Mexico. It is of a pale, dull tawny color, with spines, and stiff bristles spread over the surface of the head and thorax, and bristly hairs upon the wing-covers, sides of tergum, legs and antennae. The head is nearly cylindrical, a little flattened on top, very nearly as long as the prothorax, ribbed and grooved lengthwise, having the central ridge forked at tip, with some stripes on the cheeks, the throat, and the raised lines whitish, and the spines and bristles blackish. The antennae are nearly as long as the abdomen, the basal joint is thicker than the others, shorter than the second, and is set with stiff blackish bristles, while the third, fourth, and intervening jointlets are very slender, delicately hairy and thread-like. A rather small but very characteristic form, with the prothorax of long triangular outline, sinuated on the sides, having the front angles acuminate and the posterior ones produced into somewhat blunt processes, and with two longitudinal, flat ridges spreading apart behind, ending in prominent tubercles, presents a facies unlike that of any other group of the Reduviodea. The discoidal areole of the corium, and usually two streaks on the membrane, are black; and the end of the posterior femora is broadly clouded with brown. Beneath, on the middle of the abdomen, is a strongly elevated keel. The sides of the thorax, and the posterior coxae are striped with brown; several carinate, pale lines run across the pleura of the prothorax, and its lateral margins are ribbed and remotely spinous. It measures about one inch to the

tip of the venter, and is nearly one quarter of an inch in width across the abdomen. The undersides of the fore-femora are armed with short, acute spines, which serve to secure the bodies of the insects that they seize. It, as well as its young, lurks about the branches and twigs of trees, watching for caterpillars and other insects upon which to leap and transfix with the curved, acute rostrum, and, while holding one between the fore-femora and tibiæ, soon sucks it to death.

Our slender and smaller forms belong to the genera *Pygolanpis*, *Centromelus*, and *Psirontis*, while the broader ones, which inhabit the southern states, are members of *Narceus*, *Spilodinus*, and *Gnathobleda*. Thirteen or fourteen genera, embracing about twenty-seven species, have thus far been described from the western hemisphere, and about the same number of genera, with fifty species, belong to the eastern continents and Australia.

The Saicina are represented in the United States by the little yellow *Oncerothachelus acuminatus*. It is an oblong, pubescent insect, with the abdomen broader than the thorax, the connexiva wide, thin, curved upward, the head globose behind the transverse stricture next the eyes, the prothorax convexly lobate before a deep transverse impression, and with an impressed line along the middle, the shoulders tubercularly elevated; a dark, broad stripe runs from the back part of the prothorax, expands behind, and connects with the membræ, which is of the same color. This stripe omits the tip of the scutellum, which is narrow and acuminate. The sides of the sternum, continuously with those of the venter, are pitch brown. The basal joint of the antennæ is longest and stoutest, while the three others are thread-like and dusky. It measures about one-fifth of an inch in length, and is pretty generally distributed throughout the United States, from Massachusetts to Florida, and from Minnesota to Texas. When pursued it often sets the basal joint of the antennæ back, and the following ones are erected, as if in the act of listening. Numerous individuals may sometimes be found among rubbish and weeds in low grounds, or on the edges of stubble fields, during late summer and autumn. The legs are stouter, shorter, and more simple than in the foregoing forms, the fore femora are hairy and not spinous, but the fore tibiæ are furnished at tip with the cushion which is common to most of the typical Reduviids. At least ten other families and sub-families belong to this group, but our space will only permit notices of two or three of these. The great sub-family Acanthaspidina comprehends forms greatly in contrast with those already recorded. Here the body is deeper and wider than in the foregoing, although in a few genera, such as *Conorhinus*, *Rhodnius*, and *Mecurus* it is comparatively shallow, wide, and the sides of the abdomen strongly recurved; the head is long, narrow, cylindrical, thickened behind the eyes, the ocelli placed on this stouter part, the antennæ are comparatively short, setaceous beyond the second joint, and the eyes are transverse, prominent, and placed well down against the throat. The prothorax is triangular, longer than wide, the front lobe convex, generally divided along the middle by a depressed line, and bounded behind by a transverse, incomplete, impressed groove; and the legs are moderately short, hardly incrassated, but with the hind pair much longer than the others, while the spongy pit at the end of the tibiæ is either minute or absent. This and the following sub-families may be included in the great family REDUVIIDÆ, which differs most prominently from the Stenopodidæ in having short coxæ, never more than three times as long as their thickness, having the fore legs set farther back, and the thoracic segments more concentrated.

A formidable member of the sub-family is the *Conorhinus sanguisugus*. It is a

very showy species, of a pitch brown or black color, with red patches on the sides of the prothorax, spots of the same color at the base and apex of the wing-covers and bands on the sides of the abdomen. It is rather bald, most of the surface is either wrinkled or rough, and the end of the scutellum is long and sharp-pointed. It measures more than three-quarters of an inch in length, but specimens sometimes occur which are dwarfed to about one-half of an inch.

It seems to be widely distributed in the southern United States, extending from Maryland to southern Florida, and in most of the other sections from central Illinois to the Mexican boundary. The young forms of this insect bear considerable resemblance to the common bed-bug, although they are much larger, but the adult, at least, is known to infest beds, and causes severe pain to human beings by piercing them with its rostrum. Various other kinds belonging to the same genus inhabit the southwest, as also California, Mexico, Central and South America, and one species, *C. rubrofusciatus*, is common in many parts of both hemispheres.

The genus most largely represented on the American continent is the sub-tropical and tropical *Spiniger*. It already includes about fifty species, most beautifully colored, presenting great variety in pattern, and strongly defined by the presence of long spines upon the shoulders and front angles of the prothorax. Several of the species are velvety black, marked with orange spots and stripes, others are spotted and banded with red on a black ground, while still others are bright yellow, varied with black. Brazil is the central home of this genus, from which the species spread away in all directions, some being found as far north as Mexico.

A variety of the European *Opsicetus personatus*, which Dr. Stål has described as a species *O. pungens*, referring it to the *Reduvius pungens* of Maj. Le Conte, is sometimes common in the Atlantic region, where it frequents bed-rooms, living upon bed-bugs and other insects. Like its transatlantic progenitor, it covers itself with dust and fibrous rubbish in the young stages, and thus concealed it lurks in quest of prey about the corners and dark places in the rooms.

The Ectrichodiina are represented in the middle and southern states by *Ectrichodia cruciata*, a broader and deeper form than the foregoing, with a callous, thick prothorax, notched each side, and with an impressed line running forward and crossing the transverse one; the head short, thick, globose behind the eyes, and with but a vestige of a neck. The antennæ are moderately short, but stout and hairy, while the sides of the abdomen are broadly rounded and thickened. The legs are also short, the fore thighs are decidedly thickened, and the spongy fossette on the end of the fore shanks, beneath, is large. Its color is bright red, polished, with black on the cheeks, the centre of the vertex and of the prothorax, the scutellum (excepting the tip), the wing covers, sternum, knees, ends of the shanks, and bands of the tarsi. The antennæ are dusky, hairy, and the short, thick rostrum is more or less piceous. It measures about half an inch in length, and is distributed from New England to Florida and Mexico. In the north it is commonly shorter winged than in the extreme south. A variety of it occurs as far south as Panama and Central America.

Hammatocerus has one large form in the United States, the *H. purcis*. It is the type of the sub-family Hammatocerina, characterized by the generally flat upper surface, the moderately long head, sunk into the thorax almost up to the large, round, very projecting eyes, which do not embrace the throat, and by the antennæ being short and slender. The species is coarsely granulated, closely set with short, stiff hairs, the ground color is black, dull above, but polished on the venter and base of the

sternum, a broad, common yellow band covers most of the corium, while the greater part of the hind femora, and the middle of each segment on the connexiva are bright red. Two large yellowish spots are also more or less developed upon the base of the venter. It is a large and conspicuous species, measuring about an inch in length, which inhabits Virginia, and all the States further south, extending to southern Texas. By means of intervening varieties we are now able to place the black-legged Mexican form, and that with red bands upon the femora from New Granada, as local varieties of the species belonging to the United States.

Closely following these we meet with the sub-family Piratina, composed of narrower forms, with the head well drawn out in front of the eyes, the antennæ stout, tapering towards the tip, a transverse, impressed line behind the eyes, a somewhat bell-shaped prothorax, divided into two portions by a transverse constriction, and with impressed lines, especially upon the front lobe. The femora are stout, the legs short; the tibial cushion is very large, and the anterior coxæ are lengthened. Several common forms occur here, the most widespread of which are the two species, *Melanolestes picipes* and *M. abdominalis*. The former is black, with piceous legs and antennæ, while the latter has the sides and sometimes also the whole upper surface of the abdomen red. Both are common, beneath stones and rubbish, in the Atlantic and Gulf regions of the United States, and a few specimens have been captured in Mexico and California. They are active, blood-thirsty insects, and inflict a severe wound upon the hand of the incautious collector.

Sirthena carinata is another form, narrower than the preceding, but quite noteworthy for its rather elegant appearance and gay colors. It sometimes measures nine-tenths of an inch in length, has a pitch-black ground color, with a long red spot at the base of each wing-cover, and more or less of the same color on the sides of the abdomen, while the legs are honey-yellow. It is less common than either of the foregoing, and appears to be at home chiefly in the states south of New York.

The genus *Rasahus* has numerous representatives in various parts of sub-tropical and tropical America. Our only species is the *R. biguttatus*, which has not yet been found north of Virginia. It seems to be common in Florida and Texas, and has also been found in California, Mexico, and Cuba. Its ground color is chiefly dark brown, more or less pitch-colored beneath, with the legs, margins of the abdomen, the rostrum, and basal-joint of the antennæ honey-yellow; while there is an orange arc at the base of the wing-covers, and a round spot of the same color near the base of the membrane. It is one of the predatory forms which lurks on the branches of trees and bushes in quest of insect prey; and measures about three-quarters of an inch in length to the tip of the wing-covers. At least a dozen species of these insects inhabit Mexico, Central America, and Brazil, agreeing pretty generally with the above in the black or brown color of the surface, and having varied markings of yellow or orange.

The sub-family Apiomerina constitutes a large group in America, of which several species inhabit the United States. One form only, *Apiomerus crassipes*, is widely distributed here. It is a broad, robust, hairy form, with a stout, thick head, large, round eyes on the sides, about half-way between the base and tip, a deep, transverse depression back of the eyes, and the front bent down. The sides of the abdomen are broadly rounded; the legs are stout, hairy, and the tip of the shanks thickened. Its color is black, polished on the head, thorax, abdomen, and legs, and the sides of all the large regions of the body, excepting the head, are bright red; the tip of the scutellum is also red. It commonly measures about two-thirds of an inch in length, and

lays its eggs on the twigs and bark of the common pine trees. These hatch during the early summer, and the young may then be seen roaming over the trees in search of plant-lice and young caterpillars, which they pierce and suck to death, often holding them out on the tip of the rostrum, while keeping them from getting away by pressing down with the fore-feet. The adult insect may be found in the trees as early as March, and numbers may be beaten therefrom during the summer and autumn. This species inhabits most of the thinly-distributed pine belts, from Lower Canada to southern Florida, and varies very much in the width of the red markings of the thorax, wing-covers, and abdomen.



FIG. 325. — *Milgas cinctus*.

A still better known, but rather smaller, species, *Milgas cinctus*, represents in the United States the comprehensive sub-family Reduviina. Numerous varieties of forms are included in this very large group, some of which are almost as broad as those belonging to the foregoing, but others are quite narrow, and a few are almost linear in outline. The species above-mentioned lives sometimes in the same places as our *Apiomerus*. It is likewise quite common, and may be taken singly or in pairs upon a great variety of bushes and trees, from early summer until late in the autumn. The eggs are often glued to the bark of pine trees, covered by a waterproof gum, which effectually excludes the rain, dries and hardens, and does not incommode the young larvæ when they push up the lid-like ends

to make their way out.

Its color is a wax, or orange yellow in all stages of its existence, and it is made quite conspicuous by the black bands which cross its legs and antennæ. The giant of this group is the singular wheelbug, or *Prionotus cristatus*, of the latitude south of New York city. It is of a mouse-gray color, closely invested with short hair, and has the knobs of the head, cog-wheel crest on the prothorax, eyes and angles black, with the legs and antennæ tinged with chestnut-reddish. The female often measures more than an inch and a quarter in length, while the male is much smaller. Both sexes are formidable blood-sucking insects, able to conquer their neighbors of whatever order, and not at all backward in punishing man for sitting next their favorite trees. Like the foregoing, they glue their eggs to the bark of linden and other trees in our southern parks and gardens, extruding at the same time a gummy cement which keeps the eggs in condition throughout all the bad weather of winter, until the return of warm weather in spring.

A connecting-link between these groups and the Cimicidæ is seen in the next family, NABIDÆ. Here the body is oblong, somewhat oval behind, with a thick head, long and curving down in front, and terminating in a long, slender rostrum. The fore-thighs are thick, spindle-shaped, and the tibiæ attached to these are closely armed on the inside with minute spines. The wing-covers are either longer than the abdomen, or very much abbreviated; and the membrane has a large central areole, which is more or less penetrated by branching veins, and around which short veins branch off in all directions. Several forms of more than one genus of this group inhabit North America; and the common *Coriscus ferveus*, a pale yellowish insect, inscribed with fuscous upon the head, thorax, and body, and with dusky veins on the membrane, is distributed rather widely on both sides of the Atlantic Ocean. It secretes itself in the blossoms of golden-rod, or among the foliage of other low plants, and lives by capturing small insects. *Nabicula subcoleoprata* is an anomaly in this group. It

belongs to the same genus as the *firmus* above described, but is a wider, flattened form, of shining black color, bordered with yellow on the sides of the abdomen, and with yellowish legs; but in the winged state it is much narrower behind, and the wing-covers and abdomen are rather dusky, or piceous, than black. *Nabis* is now determined to be the genus to which Laporte and later writers have given the name *Prostemma*. It is an Oriental type not represented in the United States, but is composed of several beautifully marked, red and black insects, of more robust form than the preceding.

Australia and the neighboring islands furnish a group of small or medium sized insects of very much depressed structure, which form a bond of connection between the true Reduviids and the Aradidae. These are the HOLOPTILIDÆ, an ancient type of Heteroptera, having features of the Phymatidæ and Coreidæ, as well as of those to which we have already alluded. They are dark brown, or yellow and black insects, with a short, wide head, remotely-placed ocelli, curved second joint to the antennæ, of which the third and fourth joints are very loosely attached, and the hind shanks are in some species furnished with a brush of long bristles.

One genus has the second joint of the antennæ flattened, curved, ribbed, and notched at tip. All the prominences and edges of the body, including the antennæ and legs, are either fringed with long hairs, or set with close, short bristles. *Ptilocnemus* occurs both in Australia and Van Diemen's Land; *Holoptilus*, which has the hind tibiæ fringed with hairs and the third joint of the antennæ short, and attached before the extremity of the second, lives near the Cape of Good Hope; while *Maotys* has the prothorax triangular, the third joint of the antennæ very short, and the hind tibiæ encircled in part by a brush of curved hairs, and inhabits the island of Java. The rostrum is short, and remarkably thick in all of these genera, and one form of *Ptilocnemus* is said to live upon the vulture in the Philippine Islands.

By an easy step we now reach the family ARADIDÆ, which contains the most depressed Heteroptera in existence. The prevailing color in these is a dead-leaf brown, or fuscous, sometimes varied with reddish or pale markings. Two principal sub-families embrace most of the species, the first, Aradina, having a longer rostrum, a groove in the sternum, becoming less distinct upon the venter, a head with a more or less angular process exterior to the antennæ, and a thin, cleft, and lobate margin on the posterior end of the abdomen.

The largest species in the United States is the *Aradus crenatus*. It is of an ashy pale brown color, clouded and marbled with fuscous; its figure is broad ovate, interrupted by the expanded prothorax, which has a wing of an obliquely rounded form on each side, and four complete ridges on the disc, with a short one each side. The basal joint of the antennæ is very short, the second and third are about of equal length, nearly four times as long as the first, while the fourth is rather more than one-half the length of the third, and conical at tip. Full-sized specimens measure nearly half an inch from the apex of the long, cylindrical, granulated forehead to the end of the abdomen. This, in common with its congeners, lives beneath the loose bark of decaying trees. Great numbers of species of this group dwell in various parts of North America, from the extreme north, on the Arctic borders, to the tropics of South America.

The second sub-family, Brachyrhynchina, may be distinguished by the very short rostrum, a second process placed behind the eyes, by the thicker margins of the posterior segments of the abdomen, and by the wing-covers being confined within the boundaries of the disc of the abdomen, exterior to which the connexivum is exceptionally broad,

and sometimes expanded. *Dysodius* contains the largest species known. *D. lunatus* lives in the forests of South America, and is distributed north as far as central Mexico. It is of a rusty brown color, has the shoulders drawn out into flat, curved processes, and the sides of the abdomen are scalloped. Its full length is about three-fourths of an inch, and the breadth of the abdomen is nearly half an inch. Perhaps the most singular form of this group yet discovered is the *Euloba pallida*. It has the sides of the pronotum expanded into flat, thin, angular wings, and the sides of the abdomen are split into series of flat, thin, ovoid, acute lobes, with a rib-like, chitinous stiffener to each, which recalls the appearance of the external tracheæ of certain Odonata. It is a native of Para, and seems to be of unusual rarity in collections. Other genera, such as *Aneurus* and *Mezira*, inhabit the United States and Europe, but the greater number of these may be regarded as sub-tropical, or even tropical, in both hemispheres.



FIG. 326. — *Dysodius lunatus*.

The singular family PHYMATIDÆ may be placed next to these, although it has various elements of structure which point to groups which we have long since passed over. Thus, the fore tibiae resemble those of the Naucoridae, the head conforms to the type of *Aradus*, the keels on the prothorax are those of the Holoptilina, and the principal make-up of the insect, with its short, stout, curved rostrum, places it in very close affinity to the raptorial Reduviidæ. Our common North American *Phymata erosa* is a yellow insect, greenish when fresh, marked by a broad black band across the angular and expanded part of the abdomen, and with some black spots on the head, thorax, and scutellum. The fore-femora are very broad, curved, and granulated, with an oblique tooth opposed to the tip of the tibiae, and a smaller tooth on the stout, long coxæ. The female is larger than the male, and commonly measures about four-tenths of an inch in length. In this species the head is rather broadly notched at tip, and the ends each side are a little turned up, long, triangular, but not acute. It lives in numbers upon the flowers of golden-rod and various other plants in meadows and gardens, and, concealing itself, awaits the approach of a bee or other insect, when it suddenly makes a stroke with the fore tibiae, draws the insect to its beak, and there leisurely proceeds to suck the juices. Numerous species of this genus inhabit our southern states, and still others Mexico, Central America, the West Indies, and tropical South America, but those of the old continent are very few in number, and much less remarkable in appearance.

Another genus, *Macrocephalus*, is shared by North and South America, but the species are generally different in each country; and the West Indies have still other forms, which are even more beautiful and curious.

Next to these is placed a family of exceedingly feeble and generally small insects that attract the attention by reason of the vast numbers which collect upon the leaves of various trees and shrubs. They are the TINGITIDÆ, which may generally be recognized by the gauze-like meshes of the wing-covers, which lack the membrane, and generally have these organs, together with the sides of the prothorax, very thin, almost transparent, and widely expanded beyond the body. Over the head a hoodlike process, also full of meshes, often projects forward, or in some forms more simple processes are present and modified in a variety of ways.

Corythuca arcuata is a common example of this group, which lives, sometimes in great numbers, upon the leaves of several kinds of oak trees. It occupies the under-

sides of the leaves, like all its congeners, lays its eggs next the midrib and veins, and remains attached there by its rostrum, drawing the sap, from midsummer until the frosts begin to be felt in autumn. It is of a white color, with a black, shining body beneath the scale-like, meshed covering, and has a band across the base and another at tip of the wing-covers, a few traces on the crests, sides, and base of the prothorax, as also before the middle of the scutellum, either black or dark brown. Many degrees of variation occur in the width and size of the black markings, so that in some individuals these are reduced to mere vestiges. It measures at most about two-twelfths of an inch, but is often much smaller. As far as at present known, it is pretty generally distributed throughout the eastern side of the United States, and occurs also in Lower Canada. In Mexico and the West Indies it is replaced by other closely related species. *C. ciliata* is almost uniform white, and abounds upon the sycamore; while *C. juglandis* lives upon the butternut, and *C. gossypii* infests the cotton-plant. *Gargaphia* is a closely-related genus, having a wider prothorax and broadly-rounded wing-covers, destitute of the short spines which margin the thorax and costa of the preceding genus. One species lives upon leaves of beans, and another sometimes abounds upon the black alder. About forty genera, embracing hundreds of species, belong to this family, many of which inhabit the United States, but which for want of space cannot be noticed at the present time.



FIG. 327. — *Gargaphia arcuata*.

We now reach the family CIMICIDÆ, composed of two prominent sub-families. The first is Anthocorina, represented by chiefly minute, long-oval, narrow-headed forms, of a black, shining, or dull brown color, marked with white. The thorax is sub-conical in front, or flat and transverse, the antennæ are filiform in the genus *Anthocoris*, which contains our largest black species, ornamented with reddish and white, or they taper to a fine point in the dull brown ones, such as *Lytocoris* and *Dolichomerus*.

That pest of housekeepers, the bed-bug, *Cimex lectularius*, is the representative of the second sub-family, or Cimicina. The head is broader, and the frontal narrower division is bluntly rounded, not conically produced, as in the preceding division; the antennæ have the two basal joints stout, the first being very short and much thicker than the second, while the two end joints are very slender and more pubescent; and the rostrum is slender, excepting the base and extends to the fore coxæ. This species has been distributed over most parts of the world, chiefly by the agency of man, and, as might be expected under such circumstances, is subject to much variation in the relative size, proportions, and forms of most parts of its body. Full-fed and gross specimens are often quite coarsely punctured and hairy; while their half-starved brethren have a much thinner outside integument, and finer punctures, with less conspicuous pubescence. Some specimens have the wing-pads hanging loose, as if ready to change into wing-covers, but generally these are run together in one piece on the middle line. Thus far no individuals of this insect have been met with fully winged.



FIG. 328. — *Cimex lectularius*.

Immediately next to the Cimicidæ are placed the PHYTCORIDÆ, recorded in many of the handbooks as Capsini or Capsina. These Heteroptera are usually of medium or small size, but include so many differences of shape throughout the various genera that it is impossible to draw them all into one common formula. The section to which *Miris* belongs is composed of elongated forms, with very long antennæ, having the basal joint thick, long, and often very bristly, while the head has an incised line along the middle. Nearly the whole family has the fully-winged forms furnished with a looped nervure at the base, which is generally bounded on the inner corner by a narrow and long areole. These insects are either destitute of the usual pair of ocelli, or these organs are so minute as not to be detected without special preparation for the microscope.

More than a dozen divisions have been founded in this great family, of which the principal belonging to North America are Miraria, Miridiaria, Clivinemaria, Loparia, Phytocoraria, Capsaria, Bryocoraria, Cyllacoraria, and Plagiognatharia.

In such a group as this, the eye is bewildered by the excessive variety and number of patterns of ornamentation which are present on every hand; while the mind is delighted with their graceful proportions and light elegance of form, as well as by the natural ease of their quick motions. Many of these insects are soft and tender, with legs and antennæ easily detached, while others are tougher, more compact, and have a crustaceous outer integument. The antennæ are either thread-shaped, taper very slender to the tip, or have the last joint a little thickened; these organs are generally long and four-jointed in all the species. In the genus *Eucrocoris* they are nearly twice as long as the body, and the insect resembles a slender *Alydus*, or still more some of the blunt-headed Berytina. The black species of *Monalonion* very closely mimic some of the small Ichneumonidæ.

In America the most superbly colored and largest species belong to the Loparia. The Brazilian *Resthenia pyrrhula* belongs here; it is opaque black, with the thorax, breast, scutellum, and base of the wing-covers either red or orange, and measures seven-twelfths of an inch to tip of the wing-covers. A still larger species, which inhabits the vicinity of Rio de Janeiro, measures three-quarters of an inch in length, and is also opaque black, with the head, thorax, breast, base and tip of wing-covers, and base and side margins of venter blood-red; the red of the prothorax is interrupted by three short, black stripes, and the tylus is also black. It may be called *Resthenia cardinalis*. The southern United States are well supplied with representatives of this genus, of which perhaps the most conspicuous example is the *R. insitiva*. It is black, with an orange prothorax and scutellum; rarely the orange is replaced by red, or the head is also yellow. Once in a while the scutellum is black. It measures about four-tenths of an inch in length to tip of the wing-covers. Specimens may sometimes be found settled upon low plants in the alleys of oak woods, where the soil is damp and rich. The young occur upon wild blackberry and other bushes in similar situations during the early summer, while the fully adult appears in July.



FIG. 329. — *Paecilacapsus vittatus*.

The Capsaria are also broadly ovate forms, but in the United States not generally so richly colored as the Resthenias, yet one or two species are very pretty and well worthy of our attention. One of these is the *Pæcilacapsus vittatus*, a bright yellow insect, with a shining orange head, forepart of the prothorax, and entire underside of the body; while the antennæ, two short, broad stripes on the back lobe, and a short, narrow stripe next the outer margin of the prothorax, two broad stripes running from the base each side of the scutellum to the inner angle of the corium, a narrower stripe

next to the costal margin, followed by a dot on the cuneus, and the membrane are black. Two dusky bands are also present on the femora, and one or two traces beneath the knees. It usually measures somewhat more than one-fourth of an inch in length. This species is exceedingly variable in the extent of its marking; some specimens are almost destitute of the black stripes, and others have them shortened and run together as in the variety *P. nigripes* from Mexico. The leaves of dahlias, currants, and various other garden plants and fruits are infested by this insect; but it has not yet proved to be seriously destructive in any part of the United States. *P. goniphorus* is a similar, but still more variable species, which inhabits the entire eastern side of North America, from Quebec to southern Florida, and west to the Rocky Mountains and the Mexican boundary.

In contrast with the foregoing, we notice one other form, the glassy-looking *Hyaloides vitripennis*, which belongs to the division Cyllecoraria. It and the allied genera belong to a set of forms which may be recognized by the neck-like proportions of the front of the prothorax in continuity with the head. The eyes stand out prominently on each side, like beads, and the front is bluntly rounded. Here the base of the prothorax is broadly convex, and the wing-covers are flat and long elliptical, with the costal edge strongly carinate. Its color is yellowish-white, with the front basal joint of the antennae, back part of the prothorax, and a band across the apical end of the wing-covers, red. The wing-covers are almost transparent, the prothorax is coarsely punctate, and the forward lobe of the prothorax, the last two joints of the antennae, the tip or more of the second joint, and the base of the scutellum, are black. It measures about two-tenths of an inch to the tip of the wing-covers. This elegant little insect lives in great numbers upon the wild grapevines, but it is often equally common upon the varieties of black and red oak, particularly in the early autumn, where it may be seen searching for small, tender insects and larvæ. It is distributed from Canada to Florida, and west to Kansas and Texas. A variety has the red replaced by black, and a black stripe runs along its prothorax.

A wide hiatus exists between the family just noticed and the PYRRHOCORIDÆ, now to be considered. These latter are stouter and much more heavily built, generally large insects, marked with strongly contrasting colors, in which red and black play a conspicuous part. The first sub-family of this group may be represented by the familiar cotton-stainer of the southern states, *Dysdercus sutellus*. It is oblong-oval in form, of a red color, the wing-covers and an are on the base of the prothorax, and also the scutellum, are pale brown. The wing-covers have the costal margin, a narrow line bordering the base of the membrane and continuing diagonally along the outer margin of the clavus, and also a slender streak on the inner margin of the clavus, pale yellow. The first joint of the antennae is very short, and, together with the base of the second joint, red; the remainder of the second, and also the third, fourth, and fifth joints, the membrane and the shanks, including the tarsi, are black. It varies much in size, ranging from five-twelfths of an inch to two-thirds of an inch in length. It inhabits the Bahama Islands, as well as Florida and other southern states, and everywhere produces serious damage by withdrawing the sap from the leaves and bolls of the cotton plant, as well as by staining the fibre an indelible red or yellow color.



FIG. 330. — *Dysdercus sutellus*.

The *Largina* agree with *Dysdercus* in having no ocelli, but they are generally

wider and deeper insects, with shorter and thicker legs. They have a thick, nearly triangular face, with prominent anteroniferous tubercles, antennæ composed of five joints, of which the three intermediate ones are sensibly thicker on their distal end, and the basal joint is stout and very short. The eyes are large, placed obliquely, and very prominent. Commonly the prothorax forms a broad triangle with the tip cut square off, is raised much above the surface of the wing-covers, and has the margins thick. The corium is coarse and thick, and the membrane has three principal basal areoles, from which branching veins run off. Usually the fore-femora are thicker than the others, and have a pair of short spines of different length, underneath, near the tip, and the basal joint of the rostrum is expanded at tip. This group is distinctively American, and is represented by numerous species of very varied patterns, and often richly colored, in the regions extending from the southern United States to the Rio de la Plata River in South America.

Our native species, *Largus succinctus*, which extends from New Jersey to Florida and west to Mexico, is a brownish-black, broad, ovate insect, with the upper surface especially opaque, and the venter tinged with bluish by the coating of fine pubescence spread over it. The prothorax is margined each side and behind, likewise the edge of the abdomen and costal margin of wing-covers with orange, or red, and the trochanters, together with the bases of the femora, are of the same color. It measures somewhat more than one-half of an inch to the end of the abdomen. Numerous varieties of this insect have been met with in various parts of Florida and Texas. The males are generally much narrower than the females, but occasionally both sexes are equally narrow. Our species live along the borders of oak woods in Maryland and Virginia, appearing fully adult in the months of July and August. The young stages are of a brilliant steel-blue color, with reddish legs, and a bright red spot at the base of the abdomen. Specimens from the sea coast of Florida are of a pale tile-red color above, and bluish-gray beneath. The tropical species are more gaily colored than those from Mexico and the United States, and each geographical province has two or three species peculiar to itself.

Acinocoris and *Theraneis* have narrower bodies, and the former has unusually prominent eyes. *Araphe* is remarkable for having a nearly globose head attached to a much narrower bell-shaped prothorax.

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The family LYGEIDÆ, which comes next to the group just indicated, is sub-divided into about nine so-called sub-families, which differ from each other chiefly in details of the parts of the prothorax. Thus the first, Lygeina, is composed of forms which bear a close resemblance to *Dysdercus*, and, in common with all the rest of this family, have a pair of very distinct ocelli between the large eyes. The nearly conical head is set well back into the prothorax, so as to bring the eyes directly in contact with the latter, and project beyond it. These are chiefly red insects, banded with black across the wing-covers,

of which a familiar example is the *Lygeus fuscatus*. This species has the legs, antennæ, rostrum, sides and middle line of the head, disc of the prothorax, scutellum,



FIG. 331. — *Largus succinctus*.



FIG. 332. — *Lygeus fuscatus*.

most of the breast, dots along the sides of the abdomen, its tip, and two spots each side of the middle of the venter, black. It is a large species, measuring about two-thirds of an inch to the tip of the wing-covers, and is pretty generally distributed throughout the warm and sheltered parts of this continent, and wherever the larger varieties of *Asclepias* flourish, either on the coast or inland. *L. turcicus* is a smaller species, with bluish-black triangular area surrounding the scutellum, a large spot of the same color on each wing-cover, as also each side of the head and front and base of prothorax. This genus is widely distributed throughout the temperate and torrid climates of the whole world, but is most largely represented in South America, where the forms assume a great many patterns of ornamentation.

Only one other type of this large family need be specified, although North America claims a very considerable proportion of characteristic genera and species. It is the *Myodocha serripes*, representing the comprehensive division *Myodochina*, and may be recognized by the long, narrow figure, with a conoidal head attached to a long, slender neck which terminates in the bell-shaped prothorax. Its fore-femora are swollen in the middle and armed on the under side with several teeth of unequal lengths. The color is black, with the margins, sutures, veins, and some spots on the wing-covers, the tip of the scutellum, and the legs pale yellow. There is also a black band near the tip of the fore-femora, sometimes also on the other femora, and some traces of pitch brown on the tips of the tibiae and joints of the tarsi. It measures usually about one-third of an inch in length. The pale margin of the corium is usually contracted before the tip, and a pale dot follows it on the membrane. It is rendered very comical by the swinging of the long antennae with its thickened apical joint while running over the ground among the stones and rubbish of its favorite haunts. Meadows, and rich soils in thin woods furnish it with needed shelter, and there it may be found throughout the entire year, half concealed by bits of twigs and dead leaves, or stowed away beneath the loose fragments of rock which lie scattered over the ground. The common chinch-bug, *Blissus leucopterus*, belongs here, in the division *Blissina*; and *Nysius angustatus*, sometimes almost equally abundant in the eastern United States, is a type of the *Nysiina*.



FIG. 333. — *Blissus leucopterus*.

We now turn to the great super-family COREOIDEA. Here we find an assemblage of forms, extremely numerous, and bewildering from the endless variety of structure which prevails, and pointing to affinities in many directions. Wide differences of proportion in all the principal parts are common, and we find long and slender forms in close relationship with the thickest and broadest. The family BERYTIDÆ contains perhaps the most aberrant species of the group, which, although extremely attenuated in most of their proportions, show a close relationship with various members of the family which we have just noticed. In these the colors are chiefly sober tawny or pale yellow, with markings of black or white. *Neides spinosus* is the principal representative of this group in the United States. It is as slender as a crane-fly, of a pale tawny color, with four joints to the thread-like, long antennae, and has the tip of the basal joint clavate, and the short apical joint thick and black. The front of the head tapers off to an almost acute, upturned point, before which the face curves forwards in a long, thick keel. A distinct carinate pale line runs along the middle of the prothorax, each side of which the surface is rough and coarsely punctate; while an erect spine projects from the base of the scutellum, and another from each side of the mesopleura, just in front of the posterior coxæ. The tips of the femora are clavate,

the tarsi and apical end of the tibiae are more or less black, there is a black point at the costal apex of the corium, and the venter is marked with four dark brown lines. The membrane is exceedingly long, and has four longitudinal veins, and the sides of the abdomen, particularly of the female, are a little curved. It is about one-third of an inch in length, by about the one-twenty-fifth of an inch across the thorax. The costa of the corium is protracted like a narrow rim far beyond the middle of the membrane. It is a rather sluggish insect, which may be found in the undergrowth of oak woods throughout all the warm parts of the year; and it is distributed over most of the sheltered localities of the United States from Maine to Georgia, and west to Texas and Arizona. In the colder sections of the country, in Canada, and on the mountains of New Hampshire, North Carolina, and the northwest, it is replaced by *N. muticus*, a species which lacks the spines of the thorax and scutellum, and which has the front of the head bent down, in the form of a little horn.

Next to these the members of the sub-family Leptocorisina form a connecting link with the Alydina, and through them with the rest of the Coreoidea. Here the body and members are also long, but not so slender as in the preceding group. The head has two protracted lobes with a gutter between them, or these are split apart. The antennae are composed of four long joints, the basal one being very much longer than the head; and the membrane is long, with numerous parallel veins, those near the base being forked, while the outer margin is bounded by a narrow prolongation of the corium. A conspicuous feature of most, if not of all the genera is seen in the greatly prolonged basal joint of the tarsi. *Leptocoris tipuloides* is a conspicuous and common member of this group, occurring in the southern States and extending through Mexico and Central America into Guiana and Brazil. When fresh it is of a pale greenish-yellow color, having a dark triangular spot at the base of the membrane, and the antennae pale reddish, with the last joint piecous but whitish at base. *Protenor belfragi* is a rather more clumsy form of a pale clay-yellow color, with the head lobes well separated, and which inhabits most of the United States east of the Rocky Mountains.

The Alydina are of moderately narrow form, with a sub-conical head contracted behind the eyes, the last joint of the antennae thicker than the intermediate ones, and the hind pair of femora enlarged towards the tip and armed beneath with unequal spines. In these the corium is also protracted along the margin of the membrane, but not so far as in the preceding group, and the membrane has numerous long veins, some of which form areoles at base, and fork at tip. Several genera, such as *Alydus*, *Tollius*, and *Megalotomus*, inhabit the United States, and the species are numerous in most parts of America. Our native *Stachyocnemis* forms an exception here in having the end of the corium oblique and not narrowly produced.



FIG. 334. — *Acanthocephala arcuata*.

Our fauna is rich in the next group, Anisosceldina, some of which are very pretty and moderately large insects, but tropical America claims the richest and most elegantly colored of them all, and the species are there most numerous. The *Diactor bilineatus* of our plate is steel blue with yellow thoracic stripes. The Acanthocephalina embrace some of our largest forms, such as *Acanthocephala declivis* from the extreme southern States,

while *Metopodius femoratus* is distributed from North Carolina to Florida and Mexico. These may be recognized by the dark brown color and rough upper surface with a blade-like process projecting from the fore-head, and by the thick, curved, knobby hind-femora armed with coarse, curved teeth, and the plate-like expansions along the hind-shanks. Our Mictina embraces the largest and most magnificent species of this group, the *Pachylis gigas*. It inhabits Arizona as well as Mexico, measures an inch and three-quarters in length, and is of a velvety brownish-black, veined with bright yellow, and banded with orange across the legs and on the base of the plate on the third joint of the antennæ. The nymph is deep steel-blue, with two series of red spots on the tergum, and a single series of larger ones on the venter; while the sides of the thorax, the scutellum, and a broad band on each of the femora and tibiæ are brilliant orange. It flourishes on various species of cactus

FIG. 335. — *Pachylis gigas*.FIG. 336. — *Anasa tristis*.

common to the great desert plains. In this group occurs also the splendid Amazonian *Molchina compressicornis*, an insect rather less robust than the foregoing but with a long, sharp spine projecting from each shoulder, and the rough surface of the thorax, scutellum, and the middle of the wing-covers splendidly decorated with emerald green around the black, velvety spots. To the sub-family Corecina belongs our common Squash-bug, *Anasa tristis*, and also *Chelinidea vittigera*, an ochre-yellow, ovate form, with black antennæ, legs, sides of the head, band upon the base of the prothorax, and a spot behind the head.

The corium is slightly dusky, with pale yellow veins, while the membrane and scutellum are blackish. Several other sub-families occur here, which we can only mention by name. These are Spartocerina, Chariesterina, Mesocorina, Rhopalina, etc.

We now reach the extremely comprehensive super-family PENTATOMOIDEA, composed of the sub-families Acanthosomina, Edessina, Pentatomina, Sciocorina, Halydina, Philæina, Asopina, and the family CYDNIDÆ. Only a few of these can be indicated at this time. The old genus *Cyd-nus* is most commonly represented in North America by the shining, pitch-black *Pangæus bilineatus*. It has an indented curve on the front part of the prothorax, a head armed with an arc of rigid spines in front, the shanks closely set with longer stiff spines, while the front pair are built for digging into the ground.

FIG. 337. — *Chelinidea vittigera*.

Podisus cynicus is a large, ochreous, or pale yellow insect of broad, oval form, with the sides of the prothorax diagonal, and a quadrangular, flat head. The whole upper surface is irregularly punctate with red, which is massed together behind the head and near the sides of the prothorax, while the shoulders are acutely angular. The con-

nexivum has a series of double green spots on the segments, and there are some small spots of the same color near the front angles of the prothorax. This is our largest native species, and it is pretty generally distributed throughout the United States north of the Ohio River. Its stout, long rostrum gives it a great advantage in holding and piercing other insects upon which it feeds.



FIG. 338. — *Podisus spinosus*. a, rostrum.

Phléa longirostris, from Brazil, is a remarkable example of the leaf-like pattern common to the Phléaina. It is flat and very thin, with the broad form so conspicuous in the family at large, and has exceptionally long antennae and rostrum. The colors are green and gray, closely imitating the pale bark of various trees and shrubs.

The Halydina are chiefly broad, moderately flat, gray and brown insects, with long, slender antennae and rostrum, prominent shoulders, and uneven surface, with very branching veins to the membrane. One of the commonest forms in the Atlantic region is *Brochymena annulata*. It has a squarer head than its nearest relative, with the front rather short, a deep notch each side, and a very slight one before the tylus. The surface is unevenly punctate with black, and the membrane is distinctly marbled with the same color, while the side margins of the prothorax are moderately toothed, and the shoulders are oblique, feebly curved, and knobbed. Notwithstanding the long and slender rostrum, it is a great enemy to caterpillars and other insects, which it searches for upon the leaves and twigs of a great variety of trees in our cities and in the thin woods of the adjacent country.



FIG. 339. — *Phléa longirostris*.

Probably the largest and most varied sub-family of this assemblage is the Pentatomina. Splendidly ornamented and brilliant colored species abound in the tropics of South America, and others, less numerous, in Africa and Asia. North America has a very gay representative of this type in the *Murgantia histrionica*. It is polished blue-black, banded, striped, and margined above with yellow, orange, or red, and on the venter has seven lines of yellow and orange spots, those on the middle being largest, and the head has generally two white spots on the front.



FIG. 340. — *Murgantia histrionica*.

It plays havoc with the cabbages and other cruciferous plants, and occasionally attacks the Cucurbitae also. Prior to the late civil war it was confined to the States south of Virginia, but since that time it has spread as far north as New Jersey, and west into Missouri. Its native home appears to have been Guatemala, where it abounds, and from whence it spread into Mexico, and then across the line into Texas and our southern States. Passing by the Edessina, which have the sternum elevated into a cross, and the middle line of the venter built into a callous ridge with its base protracted forwards into a horn, we reach the Asopina, a sub-family closely verging upon the great group next to be noticed. A most superb example of the Asopus type is the *Stiretrus anchorago*. It is of a glossy steel-blue color, with orange marks on the front and sides of the pronotum, also a band at base, and narrow margin at end of the scutellum, besides the margins of the venter, large spots on its disc, and some spots on the sternum, all of the same color. Here the scutellum is nearly as long as the abdomen and more than one-half

its width, while the rostrum is very stout, and the fore-thighs flattened into plates. It inhabits the southern States, and its green and yellow variety is distributed over most of the country south of New Hampshire.

The next family, the SCUTELLERIDÆ, is very large, and comprehends a host of genera and species, most of which are tortoise-shaped, with the scutellum covering nearly the entire upper surface of the abdomen. *Pachycoris torridus* is a common but beautiful species distributed from northern Mexico to south of Rio in Brazil. As commonly seen, it is polished black, or violet, with eight round red dots on the prothorax, and fourteen upon the very convex scutellum, while the underside of the body is glossy green. It varies through all the extremes of color, from pale yellow to coal black, and the red spots run together so as to give every proportion of red, even to the extent of covering all the prothorax and scutellum. It measures about two-thirds of an inch in length. Here also belong the Corimelanina, mostly black, hemispherical insects, common all over the United States. The Eurygastrina belong to this family, and have a less deep and convex oval form, and are either gray and yellow mixed, or some shade of brown, with a long but narrower scutellum. The Scutellerina are represented by *Libysa*, which has a thick, spindle-shaped body, usually of some hue of green or blue, reflecting the light in rich variety of colors; or sometimes the surface is emerald green, covered with granulated asperities. It belongs to Africa and its islands. The family ARTHROPTERIDÆ comprehends a large assemblage of flat, very wide forms, chiefly of a black color, highly polished, marked in various ways with yellow, or sometimes yellow spotted or clouded with brown or black. All but two or three of the species inhabit the Orient, Africa, and the Pacific Islands.

Glancing beyond the vast multitude of modern species, only a few of which could here be brought into view, we are confronted by still another great assemblage, the members of which equally sustain relations to the groups already enumerated. These are the remnants of ancient faunas which have been saved to us from the wreck and reconstruction of former geological periods. Away back in the dim distance of the primitive past, when the scouring of land surfaces by floods and tides deposited beds of sediment upon the lower levels, numberless specimens of Hemiptera were caught in the moving waters and there buried in earthy matter, afterwards to become mineralized in the stony layers which have since been raised into the ridges and cliffs that we find to-day. The oldest known Hemiptera have been dug from the carboniferous shales, and these have been provisionally referred to the Fulgoridæ. But the secondary rocks, especially the lias in Europe, have yielded great numbers of fossil forms, and accordingly we have searched our own upper mesozoic plant-ledges of the Atlantic seaboard for such fossil insects, but thus far in vain.

More recent in geological time, the shales of our western tertiary formations abound in the remains of both Homoptera and Heteroptera, and the plant-ledges of Florissant, Colorado, are being made renowned by the careful efforts of Mr. S. H. Scudder, who has brought to light great numbers of species in the large order to which these pages are devoted.

P. R. UHLER.

MALLOPHAGA.

This assemblage of parasitic insects probably forms a part of the order Pseudo-Neuroptera, apparently of about the value of a super-family. Various authors have either placed them with the other *Parasita* in the order Hemiptera, or have followed Leach in constituting them a separate order under the name Anoplura.

An undoubted similarity exists between these and the Pediculidæ in some of the embryonic stages; but it is to be noticed that a departure from the hemipterous type occurs near the period of final exclusion from the egg, and that at this time a truly mandibulate mouth with the valvate labium is acquired, accompanied by corresponding modifications of the associated segments. Accordingly we accept the position given to them by the well-known Neuropterist, Dr. McLachlan, and leave the question of their relative rank to be established by future observation.

This group is composed of several families, many genera, and hundreds of species of small, or minute, commonly pale horn-colored insects, which undergo an incomplete metamorphosis (the skin being shed in pieces). They are generally detested because of the damage which they occasion to the plumage of birds, or the fur of animals. Every species of bird or beast has one or more kinds of these pests upon some one or other of the regions of its body, while, in a few cases, a single species of bird is known to harbor as many as four or five kinds of these parasites. As all of these forms are provided with jaws, they gnaw the tender cuticle at the base of the hair or feathers, cause intolerable irritation, and, by reason of their great numbers, produce wasting disorders or even cause the death of the creatures upon which they congregate.

These lice are apterous, more or less flattened, long elliptical, lancet-shaped, or broadly ovate, and the head is horizontal, shovel-shaped, and often depressed, wedge-like at tip. They have distinctly jointed antennæ and palpi, a prothorax often contracted like a neck, a mesothorax of ample proportions (often as wide as the base of the abdomen), fringes of bristles across and on the sides of the face and abdominal segments, spiracles on the upper sides of the body, short, stout legs, placed far out on the sides of the chest, and tarsi with curved, sharp claws.

Some of the bird-lice, especially such as those which inhabit the Canary bird, the pigeon, etc., are very delicate in appearance, have a translucent outer skin, and move with great celerity between the feathers. The nits or eggs are ovate, and generally glued to the roots of the hairs, or fibres of the feathers, although they may often be found lying loose in the hollow centre of reeds used for perching-sticks in the cages of domestic birds. This is a favorite place for many kinds in winter, giving them an undisturbed shelter and nidus for hatching, and where the minute young ones may sometimes be seen in large crowds.

Mr. Denny tells us that "having obtained several nits of *Hematopinus*, *Eurysternus*, and *Suis*, and placed the same in a quill which I carried in my waistcoat pocket, from the warmth they thus received I soon became sole proprietor of a family of my young friends. These I examined soon after their exit from the ova, but could not discover such a difference in their appearance as would have led me to suppose them in the larval state; the antennæ and legs were much thicker in proportion to the bulk of the whole body than when full grown: in fact, they bore pretty much the same resemblance to the mature insect that a lamb bears to the ewe, being ill proportioned in the legs, etc. In point of activity, however, they much exceeded the adults, and

moved with a degree of rapidity not usual to such insects, at least to the family Pediculidae. In many species a very great difference in color and markings is observable after each moult, so much so, that unless an opportunity of examining a series of all sizes and ages occurs, the identity of the species would scarcely be conjectured."

Two principal families include most of the species belonging to this group. The first, PHILOPTERIDÆ, may be distinguished by the persistent absence of cushions from the tips of the two-jointed, or in a few cases one-jointed tarsi, and by the filiform antennæ, which are composed of either five or three joints.

In the genus *Philopterus* (which has been divided into nine sub-genera by Piaget, based chiefly upon differences in the form of the head), we observe small insects of extremely varied patterns. Many of these are provided with curious attachments to the sides and angles of the head, and all have five-jointed antennæ, tarsi with two claws, and live between the feathers on the necks and under the wings of birds.

A striking example of this genus is the *P. (Goniocotes) holoaster*. It is pale yellow, with the margins of the broadly rounded clypeus, sides of the head and band at its base, front margin of the mesothorax (excepting the middle), the outer



FIG. 341. — *Trichodectes capre*. FIG. 342. — *Goniocotes barnettii*. FIG. 343. — *Trichodectes subrostratus*.

edge of the femora and tibiae, and the borders of gray patches on the sides of the abdominal rings deep black. The head forms a broad shield deeply cut out behind the antennæ, and again at base. A fringe of long, remote bristles also passes around the whole outer margin of the body, and a few shorter bristles are set upon the legs. It is one of the larger species, measuring about one-tenth of an inch in length; and is common upon the domestic fowl in Europe. This is closely related to, if not identical with, the form frequently found upon hens in the middle States. Dr. Packard describes an allied species, with the name *G. barnettii*, which he has found upon the same fowl in New England. It differs from the preceding in having the sides of the head nearly entire, the clypeus longer, ovately rounded, the antennæ stouter, and with the second joint shorter, and the abdomen relatively narrower.

Perhaps the most remarkable forms belonging here are those which infest the turkey and the peacock, *Goniodes stylifer* and *G. falcicornis*. The latter has attracted the attention of many observers, and because of its singular appearance has been figured in numerous text-books of natural history. It is of a bright chestnut yellow color, with wide lateral bands of liver-brown. The head is broad, with angular blunt lobes behind, marked with brown, the widely rounded clypeus is sinuated each side, and in the cavities thus formed the stout antennæ are placed. These latter organs are hooked

in the males, and serve to clasp the females while the eggs are being fertilized. It is of about the same length as the preceding species, but has an abdomen very broadly rounded, and markedly wider than the conspicuous mesothorax. It is said to be very common upon the peacock, and to be found after the death of the bird congregated in considerable numbers around the base of the beak and crown of the head.

The turkey-louse has the posterior angles of its broadly lyrate head drawn backwards in slender, long processes; the prothorax is very narrow, curvedly tapering towards the head, and angular each side behind; while the broad, oval abdomen is fringed on the sides with bundles of exceptionally long bristles. It frequents the head, neck, and breast of the common turkey. The lice of the deer, sheep, etc., have only one tarsal nail, and belong to the sub-genus *Trichodectes*.

The next great family, LIOTHEIDÆ, is composed of species, many of which closely resemble the unwinged forms of white ants and *Psocus*, having four-jointed, stout antennæ with the tip joint thickened, a generally trilobate head, conspicuous maxillary palpi, either two-jointed or one-jointed tarsi, and correspondingly with two nails, or in *Gyropus* with only one nail.

These live upon falcons, pigeons, the stork, rook, magpie, and various wading birds, such as the heron, and egret. The genus *Gyropus* lives amidst the fur of the Guinea pig, and sometimes literally swarms in places about their neck and ears. The species are yellowish, marked with chestnut brown, especially upon the head, thorax, and legs, and have a broad ovate or elliptical body, with the head lobate behind.

Much interest attaches to these little creatures, notwithstanding the disagreeable impression commonly produced by their presence upon our domestic pets. They possess such an extraordinary gathering of structural variations, have so many peculiar modes of life, and often display such a marked degree of individuality, that they deserve to be carefully studied in order to become more accurately known. During the life of their host, they know quite well how to evade the scrutiny of man, and they are often difficult to discover, even in regions of a bird's plumage where they are known to exist.

They are also extensively distributed over the greater part of the world, being found upon the roaming aquatic and marine, as well as upon the terrestrial birds and animals, and attack the lofty eagle as readily as the plunging diver.

P. R. UHLER.

ORDER VII. — COLEOPTERA.

The Beetles, or Coleoptera as they are termed by naturalists, briefly defined, are six-legged insects, which have thick and horny fore wings and chewing mouth-parts, and which undergo complete metamorphosis.

The most striking of these characters is the peculiar horn-like, opaque, usually quite rigid fore wings, which, in the beetles, are termed elytra (singular elytron), from the Greek *elutron*, meaning a sheath, a word used by Aristotle to designate the forewings of beetles. These elytra give a general aspect to beetles which make them easily recognizable as such, however much they may vary in other respects. As a rule the elytra close together, meeting in a straight line along the posterior portion of the back or dorsum of the insect, and shielding beneath them the delicate hind wings, unless hind wings are absent, as is the case with a small number of beetles. The elytra take no active part in the flight of Coleoptera, but generally are opened outward at right angles to the body of the insect, remaining at rest in that position, while the membranous hind wings perform the necessary strokes for locomotion. In beetles that have rudimentary hind wings, and in those of which the hind wings are absent, the elytron of one side usually is united firmly along the back to that of the other side, to form a single shield, which protects the abdominal portions of the insect beneath it. In one family, the Staphylinidæ, or rove-beetles, and in some less commonly known beetles belonging to other families, the elytra are much too short or too small to cover the whole abdomen, although the Staphylinidæ manage to bring the entire wings beneath the elytra by a complex system of folding.

The name Coleoptera (from *koleos*, a sheath, and *pteron*, a wing) was first employed for beetles by John Ray, an early English naturalist, in 1705, and has been generally adopted by subsequent naturalists, although Fabricius, in 1775, termed beetles Eleutherata, on account of their free maxillæ, and Schluga, in 1767, used for them the term Vaginata, from *vagina*, the Latin for sheath.

The distinct division of the head, thorax, and abdomen, so clearly discernible in most beetles, extends in less degree to their larvæ. In the larvæ the head is usually quite distinct from the following segment. The first three segments following the head, which correspond to the thorax of the imago, are often quite different from the succeeding abdominal segments of the larvæ, but sometimes they closely resemble the abdominal segments. The abdomen is usually more prolonged in proportion to the thorax and head than it is in the imago, consequently most beetle larvæ have a vermiform appearance, which has given rise to popular names, such as 'meal-worm' for the larva of *Tenebrio molitor*, and 'wire-worms' for the larvæ of many Elateridæ. The thicker and more fleshy larvæ of Coleoptera, such as are those often dug up about roots, or split from their mines in wood, are in popular parlance 'grubs.'

The larvæ of beetles mostly have six legs, or feet, near the anterior end of their body, that is a pair of legs for each of the first three segments behind the head — the thoracic segments. In the Curculionidæ, and in some other beetles of which the larvæ live within their food, the latter are legless. Certain larvæ have more or less developed traces of anal legs, sometimes a product of the evaginated lateral portions of the



FIG. 344. — Larva of *Blaps protracta*.

anus, and a few have a fairly developed median foot on the posterior abdominal segment. In many larvæ locomotion is aided by the evagination of little wart-like ventral processes on the abdominal segments; these processes in the *Cerambycidae* are found also on the dorsum, and have been termed discs; they aid these larvæ in locomotion within their narrow mines, and call to mind a pair of processes upon the dorsum of the fifth abdominal segment of the larva of *Cicindela*, by which the latter larva is helped to go up and down its tube in the ground.

Beetle larvæ possess, like beetles themselves, without exception, mandibulate mouth-parts, that is to say mouth-parts intended for biting, although in the larvæ of *Dytiscidae* the liquid food is sucked into the œsophagus through channels in the mandibles, as will be explained more fully when treating of that family.

Larvæ of *Coleoptera* mostly live in concealed places under very diversified circumstances; beneath stones, and in wood; in acorns, nuts, and seeds; on both phanerogamous and cryptogamous plants; in furs, woollen goods, and hair goods; a few are parasitic on other insects; others lead a predaceous life, either on land or in water.



FIG. 345. — Pupa of *Monohammus*.

The pupæ of beetles have free limbs, and one can see the form of the legs, wings, antennæ, and mouth-parts of the perfect insect; the legs are gathered together along the ventral side of the pupa, with the feet just each side of the median line, and pointing toward the posterior extremity of the abdomen; the wings and elytra are parted and often wrapped partially around the sides of the pupa, so that their apices are alongside the feet on the ventral side. Where the antennæ are especially long, as in certain *Cerambycidae*, they are arranged in symmetrical curves upon each side of the pupa. Often primary or secondary sexual characters disclose in the pupa the sex of the insect.

Beetles which pupate subterraneously, usually do so in a case or cocoon rounded out in the earth; many wood-borers form cocoons of rubbish or of shreds of wood; while true cocoons above ground are spun, or formed of a viscid secretion of the larva by a few *Cureulionidae*. Those beetles which construct no cocoon pupate upon the ground amongst the grass, or, as is the case with many *Chrysomelidae* and all *Coccinellidae*, suspended upon a twig or other object. The last larval skin may remain about the pupæ of some species of these last mentioned families. Pupæ found underground, enclosed in wood, or in other places not exposed to light, are mostly white, the beetles from them attaining their color shortly after emergence. The abdominal extremity of the pupa is generally movable, and pupæ of some species will whip their abdomen about with considerable activity when disturbed; this motion is about the only external indication of life in coleopterous pupæ.

Even as distinct as beetle-pupæ may seem to be from their larval condition on the one side, and their perfected imago on the other side, there are — as might be expected from the fact that egg, larva, pupa, and imago are serial developmental stages of one and the same insect — intermediate forms, gradations and variations in these stages. Under *Meloidæ* and *Stylopidae* forms will be further treated of wherein the metamorphoses have been modified by parasitism, that condition of existence which never fails to produce degradation and retrograde development.

The number of living species of *Coleoptera* in any country cannot be accurately determined; new species are being constantly added, and species described long ago are discovered to be varieties of other species; besides this the forms regarded by

one authority to be species will be only varieties in the estimation of another equally able coleopterologist. Gemminger and Harold's catalogue of the Coleoptera of the world, issued in parts between 1868 and 1876, contains 77,008 species described up to the time of issue. Counting omissions from this catalogue, and species described since its publication, the number of described species must now reach or exceed 100,000. In large collections there are, in all probability, between 20,000 and 30,000 more species still waiting description, and it would be rash to predict the number of species which will be found later in parts of the world as yet insufficiently explored. In North America, north of Mexico, Crotch's list, published in 1874, enumerates 7,450 species, and Mr. S. Henshaw, who has a manuscript catalogue of beetles of the above region kept up to date, informs me that the number is now (1884) about 8,950.

Species of insects which feed upon substances of commercial value belonging to one region are often transported, in one way or another, to other regions, where it is not uncommon that these immigrants become serious pests until their natural enemies are also imported, or until predaceous animals of their new home resort to them for a food supply. Thus the Colorado potato-beetle (*Doryphora decoloreata*) has spread from its original habitat in Colorado over the eastern United States, and its advent in Europe is so greatly feared that it has been a subject of legislation in several countries. Our troublesome carpet-beetle (*Anthrenus scrophularia*) was probably introduced from Europe, and the asparagus-beetle of Europe (*Crioceris asparagi*) was an immigrant that landed on Long Island, near New York city, some time about 1860, and has since done considerable damage to the market gardens which supply New York city. So, too, the meal-beetle (*Tenebrio molitor*), and the grain-weevil (*Calandra oryza*) are of European origin. A few species of beetles have become, by migration, almost cosmopolitan, but the greater number of species are confined to one continent, often to some small part of a continent, although beetles are found in every part of the world that has been explored.

In geological distribution Coleoptera have been found as early as the carboniferous; they are more common in jurassic strata, and still better represented in the tertiary and in amber.

The modes of collecting and preparing beetles for the cabinet are very varied. The beginner usually depends for specimens upon lucky finds, upon captures with the net, and upon such modes of collecting as are used for all kinds of insects, and which are described in most general works on entomology, while the experienced coleopterist studies the habits of rarer insects, and uses baits and traps to ensnare them. Some of the less-known and useful ways of obtaining Coleoptera for the cabinet are the following. Beetles and their larvæ which inhabit dung, earth, or other materials heavier than water, float to the surface of water, and can be easily discovered if the earth or dung be broken up and placed in still pools, or in a trough filled with water. For killing many kinds of beetles a 'cyanide bottle' is very useful: this bottle is made by putting a few pieces of potassic cyanide into the bottom of a large-mouthed bottle — a horse-radish bottle will do very well, if no larger one can be found — and covering the pieces of cyanide with dry plaster of paris; after the plaster has been evened down by shaking the bottle a little, water should be added, best a spray from an atomizer. When the plaster sets a firm shell will be formed, which will hold the cyanide in its place, while its poisonous vapors will slowly escape through the plaster. If the moistened and subsequently hardened portion of the plaster is only about as thick as is the glass of the bottle itself, a condition of affairs which can be regulated

easily if an atomizer is used, there is little danger of the bottle cracking by the slight expansion of the plaster in setting. As potassic cyanide is extremely poisonous, great care should be taken in handling it, the bottle should be labelled "Poison," and kept in a safe place, tightly corked, and out of the reach of children. As a general means of killing insects the cyanide bottle is unsurpassed, although a few yellow or red beetles may have their colors injured by the cyanide vapor. The cyanide is best renewed in the bottles each spring, but I have had bottles that retained their killing power several years. A successful mode of wholesale collecting with the cyanide bottle is to sweep the grass, trees, blossoms, and shrubbery of all kinds with a collecting net made of stout cloth, and then to empty the whole mass from the bottom of the net into the cyanide bottle, where the insects will be killed, and can be picked out at leisure. Of course this rough mode of treatment injures some beetles, but, on the whole, it is a very productive way of collecting. In the spring leaves and rubbish from the corners of pastures, and from the woods, can be sifted, by putting them in a stout cloth bag, of which the bottom is made of wire-cloth such as is used to make coal-sieves, and shaking the bag vigorously over a piece of white cloth. The finer bits of rubbish, together with numerous torpid beetles that have hibernated beneath the leaves, will fall through the sieve upon the cloth, and the insects can be easily seen. The contents of the cloth beneath the sieve may be tied into cloth bags and taken home for subsequent and more thorough examination. In the same way the rubbish deposited by spring floods of rivers may be carried home for later examination on a surface of white paper. A single drop of strong ammonia water may be used to drive the beetles from the rubbish on the paper; too much ammonia, however, kills them, and then they are not readily found. Water-beetles are often attracted by leaving a dead mouse or other small animal to decay in shallow water; the place should be approached cautiously a number of times daily, and the insects about the bait quickly netted. Beetles which feed in bark and in toad-stools, and which run from their holes and drop when disturbed, are easily trapped in large numbers by the use of a bottle partly filled with strong alcohol, into the cork of which a small tin tunnel has been inserted. The tunnel should be held close down beside the toad-stool, the latter suddenly picked and held over the tunnel, and now and then jarred with the hand. The beetles run out, drop, and tumble directly through the tunnel into the alcohol. In this way I have taken repeatedly as many as fifty specimens, mostly Staphylinide, from a single toad-stool. Many leaf-eating beetles and their larvæ, as well as other insects, are taken by holding an inverted umbrella beneath bushes and weeds, and then shaking the plants vigorously; the insects drop into the umbrella, which is still more useful if it is made of white cloth to enable one to see them distinctly. A hatchet, for winter collecting under bark, and, in summer, a trowel for digging, are useful accessories of a coleopterist's outfit.

Beetles should always be pinned for the collection through the right elytron, about one-third of its length from its forward end, and pins made purposely for insect collections should be used. These pins are slender, sharp, about one and a half inches long, thus lifting the insect up from the surface on which it is pinned, and lessening the danger of breaking the specimen. On the under side of beetles the pin should pass out between the middle and hind legs on the right side, care being taken not to have it pass through or push off any of the legs. The beetles should be slid upwards on the pin until about three-eighths of an inch of pin is left above the elytron. No specimens should ever be pinned in such a manner that the head or one side is droop-

ing; if there is any difference, the head should be slightly elevated, but not enough so as to be noticeable. Some collectors take pains to spread out the antennæ, palpi, and legs of their beetles, but this is useless work, and renders these organs more liable to be broken off in handling the specimens.

Very minute beetles are gummed upon small slips of paper or of mica, and these slips then pinned in the collection. A convenient kind of slip is a narrow triangle of stiff white paper, the triangle about one-fourth of an inch long, and one-sixteenth of an inch wide at the larger end. The beetle is gummed—with a mucilage of gum tragacanth or of shellac—neatly across the pointed end of the triangle, which is then pinned through its broad end, and arranged in the collection.

The cabinets used for collections of insects vary with the taste of the collector: some use boxes arranged on shelves like books, others cases into which boxes are slid as drawers. The essential conditions are that the boxes have a depth of a little over one and a half inches, in order to admit the insect-pins erect; that the box close very tightly, to exclude museum pests, those little beetles which damage or devour specimens; and that the boxes be made with very soft wood bottoms, or be lined on the bottom, inside, with cork, felt, pith, or some soft material in which the pins can be stuck without difficulty. Specimens should not be kept exposed to light, for many of their colors fade, and in a few years the collection which has been thus exposed loses its beauty as well as its scientific value. Good taste forbids the use of bright-colored surroundings or colored paper to line boxes for an insect collection; white paper lining exhibits the colors of the specimens best. Insects should be labelled in the collection neatly, and with small labels. Anyone who wishes to study insects scientifically should add the locality of capture on the label of each specimen, and a number by which to refer to a note-book, in which may be recorded the date of capture, habits, food, and other particulars of interest concerning the specimen.

The thought of observing the habits of beetles leads one quite naturally to a consideration of rearing beetles, for by rearing them, and keeping careful notes on their habits, one not only advances science materially, but also derives beautiful specimens for the collection and pleasure from the occupation. Some beetles are easily reared, taking but a few weeks to undergo all their transformations, others require several years for their metamorphoses, and are very difficult to rear. Even in Europe, where entomology has been longest and most thoroughly pursued, only a small proportion of all the species of Coleoptera have been reared, and their earlier stages observed. In other countries still less has been done. Without elaborate directions, filling many pages, it is impossible to explain the devices used to rear beetles; the only general directions that can be given are to keep the immature beetles in conditions that are, as far as possible, the same as those in which the same species live in a free state. To establish and maintain these conditions in breeding-jars, or in other places where the different stages of the insect can be observed, requires much skill, and adds pleasure to successful beetle-raising. Fungus, bark, decayed wood, dead twigs, acorns, nuts, and in fact almost any vegetable substances collected at certain seasons of the year, and put into fruit-jars, the contents of which should be now and then somewhat moistened, avoiding an excess of moisture, which often causes mouldiness, will disclose beetles whose larvæ feed on the substances put in the jars. The leaf-feeding larvæ of beetles usually attain full growth in a short time, and are conveniently bred under a bell-glass, or tumbler, inverted over a plant-pot full of slightly moistened earth. The larvæ of water-beetles are reared, without much difficulty, in small aquaria, feeding

them with flies and other insects, care being taken that the full-grown larvæ have opportunity to crawl out of the water and into moist sand, in which latter they pupate. Carnivorous land-coleoptera are more difficult to rear. Where a large number of the same species of beetle is reared at once, specimens of each stage should be preserved in alcohol, carefully labelled, for future reference.

In bodily form the Coleoptera present every variation from long cylindrical to nearly globular, from hemispheres to extremely flattened discs, from straggling ant-like forms to compact seed-like ones, as may be seen by examining the illustrations which follow. Throughout all the diversity of form which environment has given beetles, they invariably show, with considerable distinctness, a division into three parts, portions which, at first sight, might easily be mistaken for head, thorax, and abdomen, but which more careful examination proves to be head, prothorax, or the first of the three divisions of the thorax, and a portion, covered generally by the elytra, which is composed of the mesothorax or middle portion of the thorax, the metathorax or posterior part of the thorax, and finally the abdomen. The head bears for appendages the antennæ and mouth-parts; the prothorax, the first pair of legs; the mesothorax, the elytra and middle pair of legs; the metathorax, the wings and hind pair of legs; the abdomen, only the genitalia, which are usually concealed in beetles. The prothorax moves with considerable freedom on the mesothorax, and this articulation is a character of importance in the separation of the Coleoptera from the Hymenoptera, Diptera, and other insects, in which the three divisions of the thorax are more or less firmly united together. These divisions, head, prothorax, mesothorax, metathorax, and abdomen, with their appendages, merit much further consideration.

The head of Coleoptera, both in their larval and adult states, bears the mouth-parts directly forward and slightly downward as in many Carabidæ, or directly downward toward the surface on which the insect is standing, as in many Chrysomelidæ. Laterally the head of the adult beetle bears compound eyes, usually large, and the antennæ are generally just in front of the eyes. With few exceptions, among which may be mentioned certain Dermestidæ, ocelli are absent in the imagos of Coleoptera; the compound eyes are absent or functionless only in a very few cave-inhabiting species. In the larvæ, where compound eyes fail, there are often ocelli—from one to seven, usually six, on each side.

The antennæ, which are not only organs of touch, but much more olfactory organs, present considerable diversity in form in adult beetles. Often these organs are better developed on the male than on the female, becoming marked secondary sexual characters; this is especially the case with the lamelliform antennæ of some of the species of Scarabæidæ. In certain families the antennæ are not very conspicuous, and can be hidden in grooves, as in the Elateridæ; in other families, as in the Cerambycidæ, the antennæ are prominent organs, often, in the last mentioned family, exceeding the length of the insect, in some species double or treble its length. In a few families, as in the Scolytidæ, which have very small antennæ, important generic characters are found in these organs. The antennæ of beetles may have from two to thirty-four joints, but eleven is the usual number. The antennæ of most beetle larvæ have but four joints; rarely they have five, three, or two joints, and in certain cases they are represented only by a very small inarticulate tubercle.

Beetles have, without exception, biting or chewing mouth-parts. More or less concealed beneath a well-developed labrum, itself articulated to the epistoma or clypeus, is a pair of chitinous mandibles. In the males of *Lucanus* the mandibles attain

an extraordinary size, and are sometimes branched. Beneath the mandibles are the maxillæ, which are more delicate and more complex than the mandibles, and which aid the latter in masticating, apparently performing the lighter and more complicated part of the work. The basal articulation of each maxilla is termed the *cardo*, to this is attached the *stipes*, with an external scale-like segment, the *squama palpigera*; to the *squama palpigera* a multiarticulate palpus, the palpus *maxillaris*, or maxillary palpus, is jointed. Two lamellar lobes, the real chewing-organs of the maxillæ, are also attached to the upper edge of the *stipes*; these are termed, respectively, the *lobus externus*, and the *lobus internus*. In the *Cicindelidae*, *Carabidae*, and *Dytiscidae*, the *lobus externus* is palpiform and usually two-jointed. The maxillary palpi generally have four joints. Beneath or behind the maxillæ is, homologically, a third pair of buccal organs, a second pair of maxillæ, the two halves of which are united together at their bases, which latter are also united above with the *ligula* or tongue, and below form the *mentum* or chin. The *ligula* and *mentum*, the last of which articulates with the lower portion of the head by the gular suture, are important in the classification of *Coleoptera*. Joined to each side of the *ligula* is a palpus *labialis*, usually three-jointed. A membranous process usually exists on each side of the *ligula* near its tip; these processes are the *paraglossæ*.

The *labrum* above and the *labium* beneath, in *Coleoptera*, as in other chewing insects, are passive in function, serving to hold the food in place while it is masticated by the mandibles and maxillæ. As the cheeks in higher vertebrates prevent a side-wise or lateral squeezing out of the food from between the teeth, so the *labrum* and *labium* of *Coleoptera* keeps the food in its position between masticatory organs which operate laterally. All the mouth-parts of adult *Coleoptera* are subject to slight modifications and reductions in certain families and genera, and in the larvæ the oral organs are not rarely considerably modified. The larvæ of *Dytiscidae* and *Hydrophilidae* present remarkable modifications of form and use, which, as in the case of other striking variations from the normal form of larval mouth-parts, will be described under their respective families.

The *prothorax*, the middle of the three portions into which all beetles are divided with considerable distinctness, is hollowed out in front to receive the neck or head, and is articulated behind with the *mesothorax*. The *prothorax* bears the forward legs. Its dorsal surface is often termed the *pronotum*.

The *mesothorax*, *metathorax*, and *abdomen* form the last of the three portions of a beetle, which portion is often called the *trunk*.

The *mesothorax* and *metathorax* are very intimately united; upon the former are borne the *elytra* and middle pair of legs, and upon the latter the wings and hind pair of legs. Both *mesothorax* and *metathorax* are hidden from view, on the dorsal side of the insect, by the *elytra*, except that in most beetles a small triangular portion of the *mesothorax* is visible between the *elytra* at their bases; this triangle is the *scutellum*. The median ventral pieces of the three different parts of the thorax are termed, respectively, *prosternum*, *mesosternum*, and *metasternum*, and the pieces which connect each of these sternal pieces at the sides with the dorsal pieces, are termed the *episterna* and *epimera*, respectively, of the *prothorax*, of the *mesothorax*, and of the *metathorax*. The sutures between certain of the above-mentioned parts may be obliterated in some cases.

The *abdomen* is broad anteriorly, is closely united with the *metathorax*, is in most cases entirely covered or protected from above by the *elytra*, and contains the sexual

and the greater part of the digestive organs. Spiracles, or breathing pores, open in the flexible membrane which connects the dorsal and ventral pieces of the abdomen. At its extremity, between the dorsal and ventral pieces, open, in a common cleft, the anal and genital orifices, and on each side are often structures of greater or less complicity, generally hidden from outside view, constituting the genitalia or genital armature. The genitalia are often more visible in pupæ, as is the case with many pupæ of Lucanidæ and Scarabæidæ, than in imagos.

While the abdomen of adult beetles have no appendages except the genitalia, a few beetle larvæ, among which are those of Gyrinidæ and Psephenidæ, have gill-appendages borne by several abdominal segments.

Adult beetles enjoy locomotion of several sorts, flying, springing, climbing, crawling, or running; a few add swimming: their larvæ sometimes swim, but more commonly only crawl or run.

The legs of adult beetles, as well as those of their larvæ, are appendages of the three thoracic segments, and are modified according to the purposes for which they are used. In some larvæ one or more pairs of legs are reduced to the merest rudiments or entirely disappear, but in the mature beetles no such reduction takes place. The typical constitution of the legs of adult Coleoptera is as follows: the basal joint, short but of various forms, is termed a coxa, and the cavities into which the coxæ are set on the under side of the thoracic segments, on each side of the median line, are called coxal cavities. The form of the coxæ is of importance in distinguishing the families of Coleoptera. Jointed to the coxa is a piece named the trochanter; the connection of the trochanter with the next following piece—the femur—is very intimate in some beetles, in others the hind trochanters are prominent lobes upon the inner side of the femora. The femur, or thigh, is the first long piece of each leg; the tibia, another long piece, follows it, and to the latter piece is jointed a foot or tarsus, consisting of from three to five short joints, the terminal joint generally having two claws, and between the claws a small appendage, the onychium. The tarsal joints are hairy beneath, and those of the anterior (and sometimes also the middle) pair of legs of many male beetles are modified to clasp more firmly the female during copulation. The most peculiar of these modified tarsi are those of the males of the water-beetles belonging to the family Dytiscidæ; their tarsi will be further described when treating of that family. The form and proportion of beetles' legs are quite varied. Legs fitted for walking and running, ambulatorial and cursorial legs as they are called, are slender, and rather long in proportion to the size of the insect. Fossorial legs, or those intended for digging, are short, stout, and flattened. Springing legs, or saltatorial legs, have generally much thickened femora. Natatorial legs, those used for swimming, are oar-shaped or paddle-shaped, and are bordered with hairs.

The elytra, which are really horny forward wings, and in which the remnants of veins often can be seen, are generally opened out nearly or quite at right angles to the body in flight, and serve to balance and to steer the beetles, while the two membranous wings, which are ordinarily hidden beneath the elytra, unfold, and, by their rapid vibrations, furnish the impulse in flight. Jousset de Bellesme thinks the elytra govern direction in flight by changing their position, and consequently altering the position of the centre of gravity of the beetle. In the Cetonians, a portion of the Scarabæidæ, the elytra are said to remain closed in flight, the wings projecting out from beneath their bases. The inflexed outer margins of the elytra are designated as epipleurae. The venation of the wings of Coleoptera at first glance appears simple, but the devices

which enable the tip of the wing to fold back, in one or sometimes more folds, without too greatly weakening its structure, are an interesting study. If one pulls open forcibly the wing of a large water-beetle (*Dytiscus*) that has been preserved in alcohol, the wing will partly close itself by its own elasticity, and such a wing furnishes an excellent object on which to study the folding mechanism.

A few beetles are wingless and cannot fly; their elytra are united to each other on the inner side, and they are said to have connate elytra. In such cases the original function of the elytra and wings, that of flight, has been superseded by a secondary function of the elytra, protection. Rarely both elytra and wings are absent, as in the females of certain "lightning-bugs" (Lampyridæ), which are thus rendered so worm-like that they are called popularly "glow-worms."

The flight of beetles is generally heavy and slow; some, however, can fly very quickly, but most rapid-flying beetles rest often from flight, and can be chased down and captured without great difficulty in an open field. A sport which children enjoy is chasing down, in this manner, the tiger-beetles (Cicindelidæ).

While the genitalia of most beetles are concealed in the abdominal segments, secondary sexual characters are so manifest in many species as to attract the attention even of careless observers. As already mentioned, the anterior tarsi of some beetles serve to distinguish the males from the females; in a few water-beetles (Dytiscidæ) fluted elytra are found in some females, while the elytra of other females of the same species are not fluted — truly dimorphic females; in many Scarabæidæ, in some Cerambycidæ, and in many other Coleoptera, the males have larger and better developed antennæ than the females have; a large number of Scarabæidæ and a few other beetles have, in the male, well-developed horns upon the prothorax, or upon the head, or upon both head and prothorax, while their females have no horns, or much less developed ones in the corresponding positions; in the stag-beetles (Lucanidæ) the mandibles of the males are excessively developed. The sex of beetles is sometimes determinable in the pupal state from their evaginated or protruded genitalia.

Beetles, or their parts, may be smooth, striate, punctate, cancellate, or may have many other modifications of surface. They may be clothed with waxy secretions, spines, hairs, or even scales. The excessive brilliancy and sparkling coloration of the so-called diamond-beetle of Brazil (*Eutimous imperialis*, of the Curculionidæ), which will be figured further on, is due to its being covered with scales: this kind of ornamentation with scales — really only modified hairs — is common among the weevils (Curculionidæ), and not rare in a few other families of Coleoptera. Beetles exhibit almost every known shade of color, and a few are iridescent with beautiful metallic hues. A little beetle (*Cryptoclyta aurichalca*) not uncommon on the wild morning-glory (*Convolvulus*), looks, when alive, like a flattened drop of the finest polished gold. The species of certain families resemble one another in coloration and figuration; the leaf-beetles (Chrysomelidæ) have, for the most part, brilliant coloration; the lady-birds (Coccinellidæ) have for prevailing colors red, yellow, and black, mostly arranged in round or roundish spots; the Tenebrionidæ are generally sombre colored, often dull black.

The internal anatomy of Coleoptera is not as varied as is that of many other insects, and the main facts can be condensed, in a general way, to the following statements:

A narrow œsophagus, into which often open salivary glands, passes into a crop, the posterior portion of which is lined, in carnivorous Coleoptera, with chitinous teeth, serving as a gizzard. Behind the gizzard the digestive tract, which has a few convolu-

tions in carnivorous beetles and more convolutions in herbivorous ones, may be designated as the ventricle. The posterior end of the ventricle is marked by the insertion of four or six long tubes, the malpighian vessels, which are urine-excreting organs. Beyond the insertion of the malpighian vessels, and ending at the anus, is the intestine, properly speaking, often showing a differentiation into small intestine, caecum, and rectum. The malpighian tubes are usually a number of times as long as the insect itself, and are coiled about in the abdomen of the beetle in a way that makes them very difficult to disentangle without breaking. Glands open into various portions of the digestive tract, among them rectal glands into the rectum. Carabidae, Dytiscidae, and some other beetles have glands opening on each side of the anus that secrete acid or strongly odorous fluids which are used by these insects to defend themselves. In the bombardier-beetle (*Bruchinus*) the secretion of these anal glands is partly gaseous, or becomes aceriform immediately after its discharge.

The nervous system consists of a supra-oesophageal ganglion, from which originate the antennal and optic nerves; an infra-oesophageal ganglion which sends nerves to the mandibles, maxillae, and labium; and a series of ganglia, connected by double commissures, just beneath the digestive tract. During the growth of the larvæ these double ventral ganglia, typically distinct and one in each segment, consolidate in various ways, so that, in the imagos, Eduard Brandt has characterized four types of the nervous system, as follows: first, a system with a supra-oesophageal ganglion and a large central nerve-mass in the thorax, of which mass the forward end is the infra-oesophageal ganglion; second, a system with two cephalic ganglia, and a central nerve-mass in the thorax; third, a system with two cephalic, two thoracic, and none to eight abdominal ganglia; fourth, a system with two cephalic, three thoracic, and none to eight abdominal ganglia. Beetles have, besides the central nervous system noticed above, a somewhat complicated sympathetic nervous system.

The circulatory system of Coleoptera, like that of all insects, is not well differentiated. A so-called heart extends along the dorsum, where it pushes the nearly colorless blood toward the head; here the blood is distributed in somewhat irregular and usually ill-defined passages. Neither venous nor arterial system exists, in the full sense of the terms, although in the mouth-parts and antennæ of the larva of a water-beetle (*Hydrophilus*), when this interesting larva is seen alive under the microscope, the blood can be observed circulating in definite channels.

Respiration is by tracheæ in the imagos, and the respiratory movements consist of alternate approximations and separations of the dorsal and ventral portions of the abdomen, causing renewal of the air in the tracheæ. Besides the tracheæ there are generally tracheal bulbs, or expansions of the tracheæ, which can be inflated at the will of the insect, and are thought to be useful in flight, by lessening the specific gravity of the insect. The stigmata (sometimes called spiracles), the external openings of the tracheæ, usually have more or less complete sieves to prevent dust from entering the tracheæ, and in some cases these sieves form, as in a water-beetle (*Dytiscus*), most beautiful objects for the microscope. Beetles have a pair of stigmata on the mesothorax, on the metathorax, and on each of the first eight abdominal segments; their larvæ generally have one pair of thoracic, and eight pairs of abdominal stigmata. Some aquatic larvæ have only the two stigmata of the eighth abdominal segment, others respire wholly or partly by gills.

The female sexual organs consist of numerous ovarian tubes on each side uniting in various ways to form a pair of oviducts, which latter themselves unite to form

a vagina, that opens into a more or less extensile ovipositor. The bursa copulatrix and receptaculum seminis are generally present as accessory organs of the vagina. The male sexual organs consist of from one to six testes on each side, opening into a vas deferens, the two vasa deferentia usually expand to form a pair of vesiculæ seminales, and then, receiving ducts from accessory glands, unite to form a common efferent canal into the extensible penis.

The eggs are covered with an egg-shell or chorion which is generally not very firm, and are rarely, as in the case of a water-beetle (*Hydrophilus*), deposited in a nest. A few beetles are viviparous, among them certain rove-beetles (Staphylinidae) and the Stylopidae. One species of chrysomelid (*Gastrophysa raphani*) has been shown by J. A. Osborne to be capable of parthenogenetic reproduction. Apparent hermaphrodites rarely occur as monstrosities wherein some secondary sexual character of one sex is borne by an individual of the opposite sex, but no real case of hermaphroditic Coleoptera is known. Copulation sometimes takes place between different species of a genus, and less commonly between species of different genera.

The muscular system needs no special description. The Coleoptera are among the strongest of insects, and Professor F. Plateau found that the common European dor-bug (*Melolontha vulgaris*) could exert a traction along a horizontal surface equal to forty times its own weight.

The sense organs are necessarily partly external and partly internal, that is they are made up of modified external parts to receive impressions, and nerves connecting these parts with the central nervous system. The olfactory organs, as already mentioned, are in the antennæ, and by their aid dung-beetles are guided long distances to their food, and certain other beetles to their mates of the other sex. Eyes and ocelli are the organs of sight. The location of the auditory organs has not been determined with certainty, but beetles surely hear, because they are often provided with sonoric organs. The sense of touch is especially developed in the antennæ, palpi and tarsi, where the fine hairs communicate with nerves at their bases. The organ of taste has not been certainly located, but possibly in beetles it is upon the hypopharynx, an extension of the pharyngeal walls just above the labium.

Allusion has just been made to the fact that beetles often produce more or less musical sounds—stridulate as it is termed by entomologists. This stridulation is produced by rubbing different parts of the body, wings, or legs against each other, and is observed very commonly among the longicorns (Cerambycidae). If one of the red and black beetles with long antennæ (species of *Tetrapes*), that are so abundant on different kinds of milk-weed (*Asclepias*) during the latter part of summer and during autumn, be pinned, in the usual way, upon the cover of a cigar-box, or upon anything else that serves as a sounding-board, the stridulation can be demonstrated to a considerable audience. By pressing from time to time upon the tip of the elytra of the *Tetrapes* the sounds will be renewed vigorously at the will of the experimenter, and the prothorax of the beetle will be seen to bend rapidly forward and backwards. The sound is produced by the rubbing of a sharp angular ridge upon the prothorax against a finely striated surface on the metathorax, a mode of sonification on a small scale similar to that where a boy runs along a fence pushing a stick against the pickets. II. Landois, who studied sound production by insects, asserts that all Cerambycidae, large and small species alike, are provided with stridulating apparatus, whether one hears their tones or not, and he draws from this fact the conclusion that beetles produce sounds beyond the reach of the human ear. In the graves-digger (*Necrophorus*)

sonification is the result of rubbing striated surfaces on the fifth abdominal segment against the posterior edge of the elytra. In a dung-beetle (*Geotrupes*) stridulation is brought about by action of the hind edge of the third abdominal segment upon corrugated surfaces on the coxæ of the posterior pair of legs. Stridulating sounds are produced by many other beetles, among which may be mentioned the following: *Prionus*, by rubbing the rough inner side of the hind thighs against the lateral margin of the elytra; *Pissolus* by rubbing the acute edge of the ventral segments against the inner edge of the elytra; *Polyphylla*, *Anomala*, *Trox*, *Ligyrus*, and *Anthonomus* by rubbing together corrugated surfaces of the metathorax and elytra. The three-striped potato-beetle (*Lema trilineata*) and some other *Chrysomelide* stridulate.

Luminous organs are found mostly in the family Lampyridæ, but the larva of an elaterid, probably of *Melinaetes*, and the famous fire-fly of tropical America, the imago of *Pyrophorus noctilucans*, another species of Elateridæ, are luminous, and will be further noticed when treating of their respective families. The mode of production of light by beetles has been the subject of many experiments and researches. Professor C. A. Young, the astronomer, has examined the spectrum of the light of a common fire-fly (*Photinus?*) and found that it was continuous, without lines, and that it extended from Fraunhofer's line C, in the scarlet, to about F, in the blue, indicating rays which affect the visual organs greatly without the production of much thermal or actinic effect.

Beetles live sometimes singly, sometimes gregariously, and inhabit almost every conceivable substance and locality; few are found in the ocean, or in salt-springs; the deepest caves are the habitats of blind species, of which those from the caves of Kentucky and of the Pyrenees have been most investigated; certain beetles are found in nests of ants and termites, and others even in mummies; there are water-beetles which inhabit hot springs; larvæ of certain Telephoridæ are often seen on snow; a few beetles, in their larval state, are parasitic in other animals, others inhabit galls on plants. The food of beetles is as diverse as are their habitats. The rule has been considered almost universal that Cicindelidæ, Carabidæ, Dytiscidæ, Coccinellidæ, and some other families were carnivorous, while Hydrophilidæ, Chrysomelidæ, and others were herbivorous. Late researches, especially dissections by Professor S. A. Forbes, have shown that species of some of these families eat much more diversified food than had been supposed previously. Of plants even the poison ivy and poison sumac (species of *Rhus*) do not escape the attacks of insects.

Beetles are attacked or destroyed by other organisms, chiefly skunks, birds, frogs, toads, and many reptiles and fishes, among the vertebrates; parasitic flies, wasps and mites, and many predaceous arthropods, among the articulates; numerous species of internal parasitic worms, among which *Gordius* and *Mermis* — so-called hair-snakes — play important parts; many species of Gregarina, protozoan forms, especially common in the intestinal canal of Tenebrionidæ; and finally, by parasitic fungi, which sometimes kill many beetles.

To avoid some of these enemies, beetles often mimic their surroundings, plants, or other insects. A common tortoise-shaped potato-beetle (*Deloyala clavata*), in New England, looks so closely like excrescences on the leaves of the potato that few birds would notice it. Another common North American chrysomelid (*Chlamys plicata*) often deceives collectors of insects by its close resemblance to a piece of caterpillar's dung on a leaf. H. W. Bates mentions that certain longicorns (Cerambycidæ) mimic closely the ill-tasting and disagreeably odorous fire-flies (Lampyridæ), even carrying

the mimicry so far as to have yellow spots on the abdominal segments to correspond with the luminous portions of the fire-fly. Other beetles imitate sticks, seeds, and parts of plants. The cocoon of a European weevil (*Cionus scrophularia*) resembles very closely the seed-capsules of the species of *Scrophularia* on which the larva feeds.

Other common means which beetles employ to escape from their enemies are dropping to the ground and feigning death, a practice of weevils; use of disagreeable odors and secretions, as is general with lady-birds; appearing as if about to bite or to sting, or rapid running and flying.

A few beetles have been made directly useful to man; indirectly a large number of them benefit mankind. Perhaps the blister-beetles (Meloide) are most evidently useful to man, since from them are derived the various forms of vesicatory medicines, known under the name of cantharides. In earlier times other beetles were used for medicinal purposes. The larvæ of the palm-weevil of tropical America (*Rhynchophorus palmivorus*), or of other large palm-weevils, are roasted and eaten as delicacies by numerous tribes in the tropics of both hemispheres. The Cossus, which Pliny says Roman epicures fattened with flour, probably was the larva of *Prionus coriarius*, a longicorn; larvæ of *Prionus*, as well as those of other large longicorns, are still eaten roasted in many parts of the world. Beetles of many species are used as ornaments: fire-flies, imprisoned in gauze or otherwise confined, embellish the evening coiffure of ladies, both in the East and West Indies; the elytra or whole bodies of brilliant tropical Coleoptera are formed into pictures, are used to trim dresses and hats, are even set in jewelry; and, in some cases, a beautiful chrysomelid (*Chrysomelus auratus*), common in the eastern United States upon species of dogbane (*Apocynum*), has helped adorn ladies for evening parties in this part of the world. In China the people sometimes derive amusement from beetles, which they confine in order to watch them fight, in the same way as they confine species of *Mantis* for like purpose.

The indirect benefit which man derives from Coleoptera is fully as important as are the direct uses to which he puts them. Thousands of species of beetles prey upon plant-eating insects, others remove refuse and decaying animal and vegetable matter, still others help in fertilizing flowers; many furnish food to useful birds and fishes, — but it is futile to specify further in this direction.

Few beetles are directly injurious to man; when they bite it is in self-defence; but their injuries to crops, forests, fruits, lumber, buildings, furniture, carpets, and books are notorious, and can be best noticed later.

Beetles are divided into four great groups (Cryptotetramera, Cryptopentamera, Heteromera, and Pentamera), according to the number of segments of their tarsi. This classification is not perfect, in that a few families or genera fall into groups where they would not belong on account of their tarsal characters, but into groups in which they must be included on account of other important characters. The late Dr. J. L. LeConte, an eminent authority on North American beetles, divided the Coleoptera into two parts, the genuine Coleoptera and the Rhynchophora or weevils, but this division has not yet met with general acceptance.

To the Heteromera are added, in the following pages, the Stylopida, a family which, according to some authors, forms an order of insects, the Strepsiptera. The Strepsiptera, for they are in all probability a separate order, have from two to four tarsal joints, according to the genus.

SUB-ORDER I. — CRYPTOTETRAMERA.

This sub-order includes beetles which have tarsi of four joints, of which one joint remains rudimentary. It contains two families, Coccinellidæ and Endomychidæ.

The first of these, COCCINELLIDÆ, or lady-birds, are approximately hemispherical beetles, mostly with brilliant coloration, generally red, yellow, black, and white, and a pattern usually of spots. Their head and prothorax are short, the abdomen with five, rarely six, ventral segments. Their legs are short, and project but little from beneath their bodies. The antennæ are short, although of eight to eleven joints, usually of eleven. Coccinellid larvæ all have a similar general appearance, are often quite prettily colored or clothed with warts and spines, and have three-jointed antennæ. Their comparatively active life necessitates good vision, which is provided for by three or four ocelli on each side of the head. The mesothoracic and first eight abdominal segments have stigmata. Pupation takes place upon fences, walls, trunks



FIG. 346. — *Mieraspis phalerata*.

of trees, and leaves, the pupa hanging by its abdomen. The larvæ of most species feed upon other insects, chiefly upon scale-insects and plant-lice. The imagos feed upon plant-lice, other insects and their eggs, pollen and spores of plants, and a few upon leaves of plants. Some species of *Coccinellidæ* are abundant on special plants, but usually because those plants harbor the species upon which they preferably feed. While pollen and spores often form a large proportion of the food of lady-birds, the latter generally prefer animal food, and are consequently to be reckoned among useful insects. When rudely handled, lady-birds emit from the joints of their legs a yellow, odorous fluid,

which is said to be the blood of the insect emitted through a pore in the joint. The eggs of lady-birds are elongate-oval, yellowish; they are deposited in groups, without covering, upon leaves and bark. Lady-birds, or lady-bugs, have received, on account of their useful habits and the attention which their pleasant coloration has attracted to them, numerous complimentary names in different languages; the Germans generally term them *Marienkäfer*, but sometimes *Kugelkäfer*, *Marienkirmchen*, and like terms; by the French they are called *vaches à Dieu*, and *bêtes à bon Dieu*. Individual colorational variation within the species is carried to its extreme in the Coccinellidæ, *Harmonia picta*, one of our native species, being so variable in figuration as to appear oftentimes in the collections of beginners in entomology as several distinct species.

Genera with numerous small species, which do not generally attract much attention, are *Scymnus* and *Hyperaspis*. The larvæ of a number of European species of *Scymnus* devour mites and their eggs, and one species is an enemy to the gall-inhabiting form of the grape phylloxera (*Phylloxera vastatrix*), while two American species are said to destroy chinch-bugs (*Blissus leucopterus*). *Brachyacantha ursina* is a common small species in America, and is hemispherical, and black with reddish-yellow spots. *Hyperaspis coccidiivorus*, one of our smallest species, is said by H. G. Hubbard to colonize upon the trunks of orange-trees which are thickly infested with certain scale-insects (Coccidæ), and to entirely free them from these pests. There is little doubt that these small species do as much good in destroying insects injurious to plants as do the larger species, but their minuteness has prevented their habits from being carefully observed.

Of larger species, *Chilocorus bicalcarus* is black, nearly hemispherical, with a single red spot upon each elytron. It is often to be found about orchards, upon the trunks of the trees, and its spiny, dark-colored pupæ are not rare, three or four in groups, in crevices of the bark. This species, as well as *C. cacti*, found abundantly on the Pacific coast, prey upon scale-insects, and are consequently among the most useful friends of fruit-growers. In Europe *C. bipustulatus* is abundant in all stages on a species of huckleberry (*Vaccinium myrtillus*).

Coccinella is hemispherical, hairless, and contains many pretty species, which have received oftentimes scientific names to indicate the number or nature of their spots. Among them, *C. novemnotata*, the nine-spotted lady-bird, has a black and white head and prothorax, and reddish elytra, on which are nine round black spots. The figures give a good idea of the appearance of this species. *C. septempunctata*, the seven-spotted lady-bird, one of the largest and commonest European species of this family, resembles in a general way *C. novemnotata*, and was used in earlier times, like some other species of lady-birds, as a remedy for toothache. Forskål, late as 1775, enumerates *Coccinella* in the *matéria medica* of Cairo, Egypt. In the accompanying figure are a few other common European lady-birds.



FIG. 347. — *Coccinella novemnotata*, pupa above.



FIG. 348. — European lady-birds. a, *Coccinella dispar*; b, *C. impustulata*; c, *Chilocorus bipustulatus*; d, *Coccinella septempunctata*, and e, larva; f, *Mircospis duodecimpunctata*.

Adalia bipunctata is our most common species, and is often called the two-spotted lady-bird. Its head is black, with two yellow spots on each side above; prothorax black, with yellow lateral portions, and a few dorsal yellow spots; scutellum black; elytra reddish-yellow, each with one central round black spot. Beneath, the epipleure are reddish-yellow; the margins of the prothorax yellow; all else black. This species hibernates in large numbers under bark, in barns, and even in houses. In early spring the two-spotted lady-birds come out of their hiding-places and lay their oblong yellow eggs in little masses upon the bark of trees, choosing localities where there is a prospect of an abundant supply of plant-lice, upon which their larvae feed. A few of these beetles brought indoors and put upon house-plants will seek out the plant-lice, and the females, if they discover a colony of plant-lice, will deposit their eggs near

them, insuring their destruction as soon as the eggs hatch. The full-grown larvae have a similar form to that of *Hippodamia convergens*, are black, with a yellowish spot on each side of the first, and another on the dorsum of the fourth abdominal segment. When ready for pupation the larva attaches its abdomen to some object, shortens and swells itself up so as to split its larval skin, and, thus freed from it, appears as a pupa in new colors and form. The spotted pupa, for the most part black and pink, is likewise similar to that of *Hippodamia convergens*. The imago, after it emerges from the pupa is, for the most part, very soft, and pale yellow, but it becomes quickly harder and darker-colored. *A. bipunctata* is especially abundant during the latter part of summer and in autumn on birch trees, probably attracted to these trees by the plant-lice which during that part of the year abound on birches.

Another genus, *Hippodamia*, contains species that are more elongated than those of *Coccinella*, and a number of them are common in the United States. *H. convergens* and *H. tredecimpunctata* are known to devour the eggs of the Colorado potato-beetle, while on the Pacific coast *H. ambigua* is also of economic value. *Megilla maculata*, which has a similar form and is often mentioned as a *Hippodamia*, besides eating plant-lice, preys extensively on the chinch-bug, and also eats the eggs of the Colorado potato-beetle. Its eggs are similar to, but smaller than those of the potato-beetle and might be mistaken for them.



FIG. 349. — *Hippodamia convergens*: a, larva; b, pupa.

Epilachna borealis, the northern lady-bird, which is honey yellow with black spots, was supposed for a long time to be the sole North American species of this family which was a vegetable-feeder. The larvae of this species feeds upon gourd, squash, and pumpkin vines, and the imago eats the same food. The larva is yellow and is clothed with black-tipped spines. The corresponding European species, *E. globosa* and *E. undecimmaculata* are phytophagous, the former often doing considerable damage to lucern, and now and then eating other plants, while the latter attacks bryony.

To the family ENDOMYCHIDÆ belong nearly four hundred described species which live, both as larva and imago, upon fungi. The species are distinguished from the lady-birds by their cylindrical palpi and long antennae, and often by their prothorax having grooves at its base, and by their elongated head, the lady-birds having grooveless prothorax and short head. The tarsi are manifestly four-jointed in some genera of Endomychidæ. The species are numerous in the tropics, many species being found in Brazil, where, according to H. W. Bates, they hold a sort of complementary relationship to the Erotylidæ, — another fungivorous family, the species of which closely resemble Endomychidæ, although the species of the former family mostly have cryptopentamerous tarsi, — in that the Endomychidæ devour small fungi while the Erotylidæ live upon large ones. The species of both families are slow in their motions and some of them are gregarious.

Mycetina vittata, one of our most common species of Endomychidæ, is flattened, reddish-brown in ground coloration, with the sutural or median portion of the elytra black, and with a black stripe along the middle of the outer portion of each elytron. This species is often found, in groups of a few to a hundred semi-torpid specimens, under half-decayed stumps, or more rarely under boards, about mid-winter in New England.



FIG. 350. — *Mycetina vittata*.

Sometimes the antennæ of species of this family are rendered quite ornamental by dilation of the last three joints, as in the male of *Phymaphora pulchella*.

SUB-ORDER II. - CRYPTOPENTAMERA.

This group includes beetles which in reality have five tarsal joints, one of which is abortive and hidden, giving them the appearance of having four-jointed tarsi.

The CHRYSOMELIDÆ, the so-called leaf-eaters, includes over ten thousand described species, none of which reach a very large size. They attain their highest development in the tropics, although found in fair numbers in all parts of the world. They are usually short-bodied, somewhat oval in outline, sometimes considerably flattened from above, and often have their head more or less concealed in or beneath the forward end of the prothorax. There are five abdominal segments; the trunk is generally covered by the elytra and broader than the prothorax, which latter is broader than the head. Many of the species of Chrysomelidæ are brilliantly colored, some with metallic or iridescent lustre. The antennæ are rarely as long as the body, are eleven-jointed, as a rule, but in some genera the number of joints is less. The mandibles are mostly split at the tip. The legs are seldom long, and consequently their walk is slow; wings fail in a few cases, for example in *Tinarcha* and in the females of *Metacycla*.

The eggs of Chrysomelidæ are laid in many cases upon the leaves or stems of plants without being covered. They are usually elongated and yellowish. The first brood of larvæ are mostly hatched from eggs laid in spring by beetles that have hibernated under bark and leaves. The larvæ of Chrysomelidæ vary exceedingly in form and habits; the head is small; the body ordinarily has thirteen segments, of which the three thoracic ones are always provided with legs, and are generally smaller than the abdominal segments; the prothorax of many species is distinguishable by its form, color, and firm consistence of its dorsum; the terminal segment of the abdomen in many species is prolonged below to form a retractile simple or bifid process which assists in locomotion, and behind which is the anus. Lacordaire classified the larvæ of Chrysomelidæ in a way to indicate much concerning their habits as well as their structure; the following is an abstract of his divisions. First, elongated, whitish, sub-cylindrical larvæ, living at the base of aquatic plants (*Donacia*). Second, larvæ which cover themselves with their excrement. Short, oblong, brownish larvæ, without special device for carrying their excrement (*Lema*, *Crioceris*). Oval, broad, spiny larvæ, bearing their excrement upon a fork attached to the anal segment (*Cassida* and its allies). Third, miners. Elongated, sub-cylindrical larvæ tapered at both extremities (*Haltica* and other flea-beetles). Oblong larvæ, attenuated at the two ends, and having lateral warts (*Hispæ*, *Odonotæ*). Fourth, short, thick, colored larvæ, generally provided with a false anal foot, often warty, and living exposed on plants (*Chrysomela*, *Doryphora*, *Gastrophysa*). Fifth, elongated, sub-cylindrical, warty, whitish larvæ, curved upon themselves at their posterior end, and living in cases on plants or in ants' nests (*Clythra*, *Cryptocephalus*).

The larvæ move slowly, eat parts of plants, usually the leaves, sometimes the roots, and each species generally confines its attacks to one kind, or at most to one family of plants, both larva and imago often eating the same plant. Not only the larvæ but often the imagos are in many species gregarious. Birds do very little to reduce the number of these larvæ, many of which have disagreeable odors, while others are protected by covering themselves with their own excrement, and still others are hidden

in cases and mines, or not noticed by birds on account of their minuteness; as a result of this immunity from attack species of Chrysomelidae often become serious pests, as is the case with the Colorado potato-beetle.

The pupal state is passed, as a rule, as follows: underground, often with slight cocoon, by the first half of the larvæ mentioned in Lacordaire's second group, and by some of those of his third and fourth groups; under water in a cocoon attached to stems of water-plants, by species of his first group; in the leaf-mines by some species in his third group; upon leaves by the second half of his second group, and by most of his fourth group; and in larval cases by the species of his fifth group.

Entomologists usually divide the Chrysomelide into tribes, divisions which, to a certain extent, coincide with the groups of larvæ before mentioned, but forms of especial interest will be discussed here in their systematic order, without further subdivision of the family.

Species of *Cassida* and allied forms are recognized by the excessively wide margins of the prothorax and elytra, and by the head being partly or wholly concealed beneath the forward margin of the prothorax, the whole insect thus presenting a flattened, roundish, scale-like aspect. Among tropical species very brilliant coloration is found.



FIG. 351. — *Mesomphalia conspersa*.

Desmonota variolosa is a round metallic-green species from South America, not rarely seen set in jewelry; its elytra are so hard as to resist the point of a slender pin. *Mesomphalia conspersa*, another South American species, which has an elevated protuberance formed by the anterior part of the elytra, is dull metallic blackish green, with velvety black in round punctures, and with six larger spots that show as burnished gold through a downy pubescence. Many of our own species which resemble *Cassida*, feed upon plants of the

potato family (*Solanacea*), upon the sweet-potato (*Ipomœa batatas*), and others of the morning-glory family (*Convolvulacea*). *Coptocycla aurichalcea*, found on the wild morning-glory, is brilliant gold-color, which is said to vary in shade with the emotions of the animal, and which disappears when the insect dies. The larva of this species was long ago described by T. W. Harris, and later by Dr. C. V. Riley; the latter added a description of the egg. The egg is about 0.04 of an inch long, of rather irregular angular form, flat, and usually furnished with spine-like appendages. They are laid singly upon the leaves of the food-plant of the larva. The larva is flat, oval, dark brown, with a paler shade upon the back, and is margined with a row of branched spines; while, by means of its anal fork, it carries over its back, as protection from predaceous animals, a parasol made of its own molted skins and excrement. Pupation takes place in a spiny, flattened pupa which is attached to the leaves of the food-plant by a sticky secretion. Unlike the pupæ of most beetles, this one does not have its legs free, although it can raise itself up at will, perpendicularly to the surface on which it is attached. The first brood of beetles emerge from their pupæ about July, having undergone their metamorphoses in a few weeks, and lay the eggs for a fall brood.

Coptocycla clarata, a common potato-beetle in New England, is very dark brown, with thin yellow margin, the transparency of which is interrupted by a dark brown patch at the anterior extremity of, and another just behind, the middle of each elytron, giving the beetle a curious turtle-like appearance, in fact the resemblance of species of *Cassida* and *Coptocycla* to turtles has given them the common name of 'tortoise-beetles.'

Chelymorpha cribraria, found on milkweed (*Asclepias*), is not as much flattened as *Cassida*, is reddish, with a number of round, black spots on the pronotum and elytra, giving it a slight resemblance to a ladybird.

Odontota has a somewhat quadrate, or wedge-shaped form, narrowed in front, distinctly eleven-jointed antennae, and coarsely punctured elytral striae. *Odontota scutellaris*, the flattened larvæ of which mine in the leaves of the locust, is a common species, whose devastation extends to a number of trees besides the locust. It is dull yellow, with a black stripe upon the suture between the elytra, a black head, and is black beneath. The larvæ appear in New England in July, and transform to beetles in August, after a short pupation in the leaves of the locust.



FIG. 352. *Odontota cubana*.

Quite a number of Chrysomelidae have the hind femora much thickened, enabling them to jump. Some of the smaller species jump with great activity, and on that account have been termed flea-beetles. Once the flea-beetles were united in the genus *Haltica*, a name from a Greek word, meaning good at jumping, but they have been divided since into numerous genera. Some of the flea-beetles hibernate as larvæ, others as imago. Many of them are seriously injurious to plants, the leaves of which they either mine or fill with small holes. In this way the leaves of tobacco are often rendered unfit for cigar-making by a species of *Crepidodera*.

Flea-beetles of the genera *Psylliodes* and *Dibolia* bore, in the larval state, in the stems and leaves of succulent plants. *P. chrysoccephala*, in Europe, devastates turnip fields, but often turns its attention to other crops. *D. arca*, a little, round blue-black beetle, often swarms in this country from May until the beginning of winter, on the plantain (*Plantago major*) the leaves of which it riddles.

The early stages of *Phyllotreta striolata*, the turnip flea-beetle will suffice to give an idea of the transformations of flea-beetles. The larva is linear, about 0.35 inch long, has an anal pro-leg; it is whitish, with head and posterior extremity light brown. The white pupa is enclosed in a little earthen cocoon beneath the ground. Pupation lasts about two weeks. The beetle is less than 0.1 inch long, black, with a wavy yellow stripe on each elytron. The larva feeds upon roots of cabbages and turnips underground, causing death of the plants; the imago eats the leaves of the same plants.

Phyllotreta nemorum, a European flea-beetle, devastates turnip-fields, while its orange-yellow larva bores the leaves of the young plants; like its American congener it eats other species of cruciferous plants. *Crepidodera cucumeris*, a black flea-beetle about 0.06 inch long, which, as its name indicates, infests the cucumber, does not confine itself to that plant, but mines the leaves of potatoes and of many other plants. *C. carinata*, a green species, sometimes injures greenhouse plants, and seems especially destructive to fuchsias. *Graptoidea chalybea*, a flea-beetle usually steel-blue, and about 0.15 inch long, is a pest to grape-growers, for it not only eats the leaves, but it destroys the buds of the grape. Its larva feeds externally on the leaves, descending into the earth to pupate. The imago hibernates, laying their orange-colored eggs in clusters on the grape leaves in the spring.

Among the large species of saltatorial Chrysomelidae, two genera, *Edionychis* and *Disonycha*, are represented by numerous species in the fauna of eastern North America, and another genus, *Blapharido*, by a single species. The species of *Disonycha* are often prettily colored. *D. alternata*, a common species on willows, is about 0.3 inch long and half as wide, has a reddish head with black eyes and antennae, a reddish pro-

thorax with two round, black spots each side of the middle, and dull yellow elytra with sutural and marginal black line from their bases to their tips, and a black line extending from the base to near the tip upon the middle of each elytron. This species is dull red with black markings beneath. *Edionychis* differs from *Disonycha* in having the last joint of the posterior tarsi globosely inflated at the tip. *Edionychis thoracica* has deep blue elytra, yellowish head and epipleuræ; eyes and antennæ are black, and the yellowish prothorax bears a few black spots. *Blepharida rhois* is a yellowish beetle above with brown blotches on the elytra, which latter are also punctate with dark brown dots. The eyes, antennæ, legs, and under side of the abdomen are dark brown. Its length is about 0.25 inch; its antennæ are set wider apart than in most flea-beetles, resembling, in this respect, *Chrysomela*, from which it is readily distinguished by its thickened thighs. Its eggs are deposited, five or six together, beneath pellets of its excrement. Its yellowish larva which is, like the beetles, abundant on leaves of sunach (*Rhus*), covers itself with its own excrement by means of its extensible anus. The larva is broader than the larvæ of other saltatorial Chrysomelidæ, thus approaching the form of larva in the genus *Chrysomela*.

Structurally similar to the larger flea-beetles, and like them having the antennæ set in close approximation between the eyes, but separated from them by their slender femora, are the genera *Diabrotica* and *Galeruca*; the species of the former genus have a carinate front, while those of the latter have a flat front with an impressed median line.

Galeruca xanthomelena is a species introduced into America from Europe, according to Townend Glover, as early as 1837, and does considerable damage to the elm in both countries. The beetle is about 0.25 inch long, oblong, brownish yellow or yellow, marked with black as follows: one or two spots on the head, three on the pronotum, and, on the elytra, a very narrow sutural line, outside of which, on each side, is a broad stripe not reaching the apices of the elytra. The yellow, oblong-oval eggs are deposited on the under side of the leaves in groups of from three to twenty or more. The egg state lasts about a week. The larvæ, of which the first brood appears in May, are nearly cylindrical, yellowish black with black markings; they change their skin three times after leaving the egg before pupation, thus having four larval stages, which last ordinarily about two weeks, but under especially favorable conditions only six or eight days. The pupa is oval, with a few conspicuous black bristles, and is found in crevices of bark or of the ground, or on the ground beneath leaves. The pupal state requires from six to ten days. There are three or four broods yearly, according to climate. The beetles of the last brood hibernate, and the few survivors of the winter lay the eggs for the first brood early the next spring. Both larvæ and imago feed upon the elm, partly skeletonizing its leaves, but of course the greater part of the damage is done by the larvæ. Each successive brood is usually larger and more destructive than the preceding one, but the majority of the last brood each year is killed by the frost of winter. In Austria the larva, as well as the imago, are said to hibernate. Dr. C. V. Riley, who has investigated this species in Washington, D. C., writes of its enemies: "Among these there are *Platynus punctiformis* and *Quedius molochinus*, which feed on the full-grown larvæ when these retire for pupation, and also on the pupæ. The larva of a *Chrysopa* (probably *C. rufilabris*) feeds upon the eggs of the *Galeruca*; *Reduvius novemarius* sucks both beetles and larvæ on the leaves, while *Mantis carolina* preys upon the beetle. Of the numerous other insects found among the pupæ under the trees, *e. g.*, *Tachyporus jocosus*, sundry spiders, myria-

pois, etc., several are doubtless enemies of the *Galeruca*, though we have, as yet, no proof of the fact. Many birds were observed on the trees infested by the beetles, but the English sparrow, which was the most numerous, did not feed on the insect in any stage of growth."

Very closely related to the numerous species of *Galeruca* is *Trichabata*. *T. tomentosa*, a common insect on species of golden-rod (*Solidago*) in the eastern United States, is about 0.4 inch long, and of a dingy yellowish brown with three dull, black longitudinal stripes on the elytra, three black spots on the prothorax, and one on the head.

Probably few persons have failed to notice the small, yellow and black striped beetles, *Diabrotica vittata*, which swarm upon cucumber, squash, melon, and similar vines, almost as soon as they appear above the ground. This beetle is elongate-oval, about 0.22 inch long; the elytra are striate; the general color is straw yellow with a black stripe along the middle of each elytron, reaching from its base nearly to its tip and a stripe covering the elytral suture; head, knees, tips of tibiae, and tarsi are black. The damage, often considerable, which this beetle does to young cucumber vines above ground is slight compared with that which its larva does to the roots below the surface of the soil. At the time when these beetles are swarming about the young vines, they lay their eggs at or just below the surface of the ground on the stems of the plants. These eggs soon hatch, and the larvæ feed upon or bore into the roots and stems of the plants for nearly a month, when they pupate in a little oval cavity which they form in the ground. The pupal state lasts about two weeks. The larvæ are slender, cylindrical, about 0.4 inch long, and nearly white; their head is brownish, and they have a brownish spot on the dorsum of the posterior segment. This species hibernates as imago, and is said to do so as pupa; the rapid growth of its larva enables it to have from two to three broods each year. In early spring, before cucumber vines are out of the ground, these beetles attack pear, peach, and other blossoms; and I have found them especially abundant on the flowers of the shad-bush (*Amelanchier canadensis*). While the beetles eat a few cucumber plants, confining their attacks entirely to portions above ground, the larva a little later cause whole plants to wither and die. It is the practice of many farmers to sow an extra number of seeds in each hill, so that, after some are destroyed, enough will still remain; others protect their plants with muslin or other screens, both from the attack of the imagos and from their ovipositing on the plants; still others sprinkle their young plants with lime, paris green, hellebore powder, or similar insecticides. Dr. H. Shimer discovered the larva of a small parasitic fly occupying the abdomen of females of this beetle, and, having bred the fly, named it *Tachina diabrotica*. The fly larva leaves its hosts when it is full-grown, and pupates on the surface of the ground, emerging from the pupa in less than two weeks. Parasitism of the imagos of Coleoptera by Diptera, as in *Diabrotica*, is not very common.



FIG. 353. — *Diabrotica vittata*.

Another species of *Diabrotica*, of a greenish yellow ground color, with twelve large, black spots—some of which are at times confluent—upon the elytra, is *D. duodecimpunctata*. The elytra of this species are not striate; the abdomen and bases of the femora are yellow. This species sometimes attacks cucumber, melon, and squash vines, and is said to damage the leaves of the dahlia, but I have found it most abundantly on the flowers of the golden-rod (*Solidago*). The larvæ of *D. longicornis*, another species, bores in the roots of corn.

No chrysomelid has attracted more attention or has been more extensively studied than the Colorado potato-beetle, *Doryphora decemlineata*. This species was first described by Thomas Say, an early American entomologist, in the year 1824, from specimens taken a few years before, on the upper Missouri River, near the base of the Rocky Mountains. This insect, as was later discovered, fed upon sand-bur (*Solanum rostratum*) in its native home, but as the cultivation of the potato was extended westward in the northern United States, this beetle found the latter plant so well suited to its tastes that about 1859 it began spreading over the northern United States at a rate which, until it reached the Mississippi River, did not exceed fifty miles a year, but at a steadily increasing rate, as it reached regions with denser population and more railroads, until in 1874, it reached the Atlantic coast in many places; a total average annual rate, according to Dr. C. V. Riley's estimate, of about eighty-eight miles. It is now so common in all the northern States and in Canada that the inhabitants of these regions need no figures or descriptions to recognize it, but the people of regions not yet infested may recognize the beetle and its earlier stages by the accompanying figures and a brief description. A figure is added of the nearly-related *Doryphora juncta*, a species which has been often mistaken, even by entomologists,



FIG. 354. — *Doryphora decemlineata*, Colorado potato-beetle, eggs and larva. On the right, *D. juncta*.

for the Colorado potato-beetle, although it does not attack the potato, but lives upon the horse-nettle (*Solanum carolinense*).

Both *D. decemlineata* and *D. juncta* have a brownish yellow ground color; the prothorax is marked with black spots, usually eighteen in number, but which are subject to variations of exactly the same nature in both species; upon each elytron are five longitudinal black stripes, two of which unite at the apical end of the elytron. In *D. decemlineata* it is, however, always the third and fourth stripe, counting from the outer edge of the elytron, that unite at their tips; in *D. juncta* it is always the second and third, counting in same way, that unite, while in the latter species the space between the second and third stripes is generally brownish. The legs of *D. juncta* are pale, except a black spot on the femur, while the tarsi and knees of *D. decemlineata* are black.

The female Colorado potato-beetle lays from five hundred to one thousand eggs during the season, from ten to forty at a time, in clusters on the under side of potato leaves. These eggs are oblong, about 0.06 of an inch long, fastened by one end, and are orange yellow. The eggs of *D. juncta* are lighter colored. The eggs hatch in about a week; the convex larvae are at first dark reddish brown, becoming paler and brighter in coloration as they increase in size. The full-grown larva is about 0.5 long, with the abdomen much convex above. Along the sides of the abdomen are two rows

of black spots, the head and feet are black, and there is a ring of the same color upon the second segment. The head and legs of *D. juncta* are, on the contrary, pale, and they have but one row of black dots on each side. The larvæ of the Colorado potato-beetle attain their full growth in from fourteen to eighteen days, and go under ground to pupate, where they form a naked yellow pupa. The pupal state lasts about ten days, so that only about a month is required for all stages together, from the egg to the perfect beetles. This enables these insects to have from two to four broods yearly, and as the females do not lay their eggs all at one time a succession of larvæ is produced, so that one may find the species in every stage of growth at any time during summer and autumn. Both beetles and larvæ feed on the same plant. The beetles hibernate underground and lay eggs the next spring.

The immense armies of these beetles which have at times attacked potato-fields, where they could be gathered by measure rather than by number, have rendered them a serious pest to farmers, and their actual destruction of whole fields of a vegetable almost necessary to human existence in some countries has caused *Doryphora* to be the subject of much careful investigation, and of some legislation. European nations have sometimes prohibited the importation of American potatoes, and fines have been imposed in England for possessing living Colorado potato-beetles.

The sudden spreading of *D. decemlineata* over an area of about 1,500,000 square miles has not only been accompanied by a change of food-plant from one species of Solanaceæ to others, but even to plants of other families. It will eat, when potatoes are not at hand, cabbage, common thistle (*Cirsium lanceolatum*), pigweed (*Amaranthus retrofractus*), hedge-mustard (*Sisymbrium officinale*), and numerous other plants, and when absolutely compelled by hunger it has been known to eat grass and the cultivated oat. Most all widely distributed insects are subject to considerable variation; the Colorado potato-beetle forms no exception, and the fact of its extensive distribution in so short a period as twenty-five years in portions of America having considerable diversity of climate, together with the variations consequent upon difference of food-plants to which it has accommodated itself, makes these variations of pattern, color, and size furnish, as Dr. Riley has observed, "interesting material for the close species makers," and indicates a fertile field of investigation of the variations which twenty-five years or less of changed environment can produce in a species the whole history of the spread of which is comparatively well recorded.

As *Doryphora* itself spread like a wave of destruction over the country, for the first few years its depredations in any region were scarcely hindered, but later, while man was learning how to poison it, lower animals were developing a taste for it. The lady-birds attack the eggs and larvæ; numerous species of Hemiptera, such as *Podisus spinosus* and *Harpactor cinctus*, suck out the juices of the larvæ; a fly (*Lydella doryphora*) lives in its larval state as a parasite within the larvæ of *Doryphora*, and has been found so abundant in places as to nearly exterminate the beetle; and the eggs and larvæ are eaten by several beetles, among which *Lebia granulata* — once not very common — has apparently increased in numbers on account of the food-supply which *Doryphora* furnishes. The above-mentioned insects are selected from over two dozen species known to attack *Doryphora*. Among wild birds the crow, quail, rose-breasted grosbeak (*Goniaphia latoriciana*), and cardinal grosbeak (*Cardinalis virginianus*); and, among domesticated birds, the duck, devour these beetles. In some cases chickens have acquired the habit of feeding upon them, and the common toad does good service in eating large numbers of them.

Among the many insecticides which are used to reduce the numbers of *Doryphora*, Paris green and London purple are generally considered best. Paris green, or as it is sometimes called Scheele's green, is an arseniate of copper often used as a pigment. It is extremely poisonous, and is diluted with twenty times its weight of flour and sprinkled with a sieve upon the potato-plants. London purple, which is a waste product of anilin manufacture, contains about forty per cent of arsenic, and although very much cheaper than Paris green it is still more poisonous, and is used in the same way, diluted with about thirty-six parts of flour. In all cases where these poisons are used cattle should be carefully excluded from the fields.

Severe cases of poisoning from handling the beetles themselves, in quantity, have been reported; likewise the vapor arising when they are killed by scalding is said to be poisonous. While such cases of poisoning are apparently authentic and are not improbable, yet the question of the poisonous nature of *Doryphora* is one that requires much further careful investigation than it has received.

Very closely related structurally to *Doryphora*, which is itself sometimes retained in the genus *Chrysomela*, is *C. clivicollis* and *C. scalaris*. *C. clivicollis*, which is often called *C. trimaculata*, is about 0.4 inch long, with deep blue head, thorax, antennæ, legs, and under-side, while the elytra are reddish orange with a few blotches of black upon them. Its reddish larva, which resembles in form that of *Doryphora*, feeds, like the imago, upon species of milk-weed (*Asclepias*). *C. scalaris* is one of a group of chrysomelids which have the elytra covered with curious hieroglyphic stripes and markings, whence they have been given by some authors the generic name of



FIG. 355. — *Chrysomela clivicollis*.

Calligrapha. The greenish-black and white imago, which is about 0.3 inch long, after passing the winter under leaves and in rubbish, appears early in the spring upon elm and linden trees and on the alder. Its eggs are deposited in May and June, and the larvæ of the first brood reach full growth by the end of the latter month. The larvæ have similar form to those of *Doryphora*, but are whitish, somewhat spotted with black. Similar species of *Calligrapha* are found on the hazel (*Corylus*), on *Viburnum*, and on willow (*Salix*).

In southern Europe the larva of *Chrysomela dilata* is nocturnal, as is the case with some lepidopterous larvæ, and comes out of its hiding places where it spends the day to feed upon a species of plantain (*Plantago coronopus*) at night. The larvæ of a few chrysomelids have a habit, when disturbed, of forcing out upon the tips of spines which are arranged in rows along their bodies, little drops of a disagreeably odorous milky fluid. These drops of a secretion, which is, of course, defensive in function, can be again withdrawn into the spines when danger is past. Professor C. Claus found salicylic acid in the larva of *C. populi*, the European species in which this peculiar secretion has been most studied. In America larvæ of *Plagioderma scripta*, *P. lapponica*, and *P. tremulæ* have similar secretions.

Gastrophysa polygoni is an oblong beetle, about 0.15 inch long, of which the prothorax, legs, and basal joints of the antennæ are reddish brown, the rest of the insect shining blue, except in the case of females when they are much distended with eggs; then the portions of the distended abdomen which the elytra cannot cover are yellow or yellowish brown. This beetle is very abundant from April to September upon common knotgrass (*Polygonum aviculare*) both in Europe and in America. The groups of yellow eggs on the leaves of the knotgrass hatch in from eight to eleven days. The yellow larvæ resort to the ground for pupation. There are two or three

broods yearly. J. A. Osborne found that parthenogenesis sometimes occurred in *G. caphnei*, a species found in England.

The most brilliant perhaps of the American species of Chrysomelidae belong to the genus *Chrysoschus*. This genus, and a few others associated with it, differ from *Chrysomela* and the forms just described in that they have the third tarsal joints bilobed. *Chrysoschus auratus*, from the eastern United States, is oblong-oval, about 0.4 inch long, of a brilliant metallic green, which, viewed in different directions, changes to deep red or bright blue shades. During July and August this species is very common on dog-bane (*Apocynum*). In the Pacific States *C. cobaltinus*, of a changeable cobalt-blue, is very common.

Belonging in the group with *Chrysoschus*, but less brilliantly colored, are *Adoncs*, *Fidia*, *Colaspis*, *Paria*, *Scelodonta*, and *Pachnephorus*. The larvæ of *Adoncs vitis* — a little pubescent black species with brownish-yellow elytra and legs, and with the first four joints of the antennæ pale — does much damage to the grape in Europe and is found in America. It is about 0.1 inch long. *Fidia viticida*, a chestnut brown species with short whitish hairs, injures the grapes in the Western States by riddling their leaves. The beetle is about 0.3 inch long. *Colaspis flavida*, a clay-yellow species about 0.25 inch long, attacks the grape, upon the roots of which its larvæ feed. *C. brunnea*, a brown species of which *C. flavida* has been considered a variety; *Paria aterrima*, a black species of about the same size as *Colaspis*; and *Scelodonta nebulosus*, an ashy gray species of like size, all feed as larvæ upon strawberry roots, the larvæ of three species being very much alike. *Pachnephorus cylindricus*, which is figured, is from Europe and northern Africa.



FIG. 356. — *Pachnephorus cylindricus*.



FIG. 357. — *Cryptocephalus confluentus*.

The species of *Cryptocephalus* are short, cylindrical, and generally small. They resemble those of *Pachybrachys*, but in the latter genus the prothorax is margined at the base and not crenulate, while in *Cryptocephalus* it is not margined at the base and is crenulate. In both genera the prothorax is nearly as wide as the elytra are, and the perpendicular head is set deeply into the prothorax; the antennæ are filiform. The larvæ inhabit little cases upon leaves of different trees. Beetles and larvæ alike have a habit of falling to the ground when disturbed, thus escaping observation. The number of species of *Cryptocephalus* and *Pachybrachys* is large, there being in the United States about forty described species of each genus. The species are usually

prettily marked with colored stripes or spots. *Cryptocephalus confluentus*, which is figured, will give a good idea of the form and of one type of figuration in these genera. It is a pretty North American species, in which the general coloration is yellow, that of the thorax being tinged with brick-red, while three black longitudinal lines adorn each elytron. Two of these lines are confluent upon the elytral suture, whence the specific scientific name. Westwood mentions that the larval cases of a species of *Lamprosoma*, a genus near *Cryptocephalus* in classification, mimic with remarkable accuracy the buds upon the bark of the trees on which the larvæ feed.

In Europe there are numerous species of a genus resembling, in general, *Cryptocephalus*, but of larger insects; this is *Clythra*. In *Clythra*, however, the antennæ are serrate and the anterior coxal cavities are confluent, not as in *Cryptocephalus* separated

by the prosternum. No species of *Clythra*, properly speaking, have been found in the United States, but a nearly related genus, *Coscinoptera*, is represented by several species. The larvæ of *Clythra* and *Coscinoptera* are case-bearers, and the larvæ of *Clythra quadrisignata*, a common European species, although normally feeding on willow, has been often found in ants' nests. A part of the life-history of our most abundant species, *Coscinoptera dominicana* has been described by Dr. C. V. Riley. The beetle is about 0.22 inch long, and is, with the exception of the yellowish brown labrum, entirely black; the upper surface is densely punctate, the under side covered with ashy gray pubescence. The eggs are attached in groups to plants, and each egg is borne upon the end of a delicate silk-like stalk, thus resembling somewhat the eggs of the lace-wing (*Chrysopa*). The egg is covered, as is also the case with the eggs of most species of *Cryptocephalus* and of *Clythra*, with markings formed by the excrement or by a secretion of the beetle. The eggs hatch in from fourteen to eighteen days, and each egg-shell serves the newly hatched larva for a case, into which it withdraws on the slightest disturbance. The young larva feeds on dead and decaying leaves of many kinds of trees. When its case becomes too small to accommodate its increased size, it cements pieces of earth upon the margins of the egg-shell, using saliva to make the materials adhere. Thus a ridged case is formed, in which the larva passes its life, probably requiring two years for full growth, and pupating finally in its case, after the entrance of the latter is sealed up and the whole case firmly secured to some surface.

Chlamys, of which the larvæ are also case-bearers, differs from *Cryptocephalus* and *Coscinoptera* in being covered with large tuberosities, and in having grooves in the flanks of the prothorax to receive the antennæ. The species generally have metallic coloration, sometimes dull; some of them, including our commonest species, *Chlamys plicata*, so closely resemble a piece of caterpillar's dung that birds would not pick them from a leaf. The eggs of *C. plicata* are borne upon short peduncles, and it has been discovered that, before they are protected by a coating of excrement or of secretion by the female, they are greedily sought for and devoured by the males. The larva feeds on oak, sycamore, blackberry, and sweet-fern, and inhabits a nearly smooth sub-globular case, which is formed, as in *Coscinoptera*, by additions to the egg-shell. Pupation takes place in the case, previously secured to a leaf by its oral end, and the imago, when about to emerge, cuts a lid from the aboral end of the case.

Two genera, *Lema* and *Crioceris*, the latter introduced from Europe, represent in North America another group of Chrysomelidae. The characters of this group may be summed up as follows: prothorax narrower than the elytra, not margined; middle ventral segment not narrowed, and last dorsal segment covered by the punctato-striate elytra; prosternum very narrow; first ventral segment scarcely longer than the second.

Lema has the prothorax constricted at the middle. The best known North American species is *L. trilineata*, a common potato-beetle. It has a reddish yellow head and prothorax, and three longitudinal black stripes on the elytra. Its yellow eggs are attached to the under side of potato leaves; they hatch in about a fortnight. The yellowish larvæ have their anal opening on the upper side of their terminal segment, and they cover themselves with their soft, greenish excrement. At the end of about two weeks the larvæ descend into the ground, free themselves of their excrement, form an earthen cocoon with the aid of gummy matter from their mouth, and pupate. Pupation lasts about a fortnight.

Crioceris has a cylindrical prothorax. *C. asparagi*, the common asparagus-beetle



FIG. 358. — *Lema trilineata*.

of Europe, was introduced into America, near New York city, about 1856, and since then has been slowly spreading over Long Island and New Jersey. The beetles that have hibernated appear in early spring, and lay their blackish-brown eggs upon shoots of asparagus as soon as the latter come out of the ground. The full-grown larvæ are about 0.25 inch long, ashy gray or obscure olive green, with shining black head and legs, and a row of small warts of the same color along each side. The pupa is enclosed in a slight cocoon, just underground or beneath leaves and rubbish upon the surface. The egg state lasts about eight days, the larval stage about twelve days, and pupation about ten days. The beetle is about 0.25 inch long, and the arrangement of its colors—black, yellow, and red—is somewhat variable. The head is black; the prothorax reddish, often with two black spots above; the elytra are yellow, with a sutural stripe of black, from which stripe extends two black bands dividing the yellow part of each elytron into three portions, which vary from three dots to three broad bands, according to the width of the black sutural stripe and its branches. Beneath the beetle is nearly or entirely shining black. Recently a second European species of asparagus-beetle, *Crioceris duodecimpunctata*, has been introduced into Maryland. The upper surface is orange red, each elytron having six black dots.

Differing structurally from *Crioceris* by their very long first ventral segment, are the numerous species of *Donacia*, found upon water-plants. *Donacia* resembles, in general appearance, the longicorns (Cerambycidae); the antennæ being inserted on the front, and filiform, while the prothorax is narrow and not margined. These beetles fly quickly from one plant to another. Their coloration is generally metallic, often bronze-green above, and they are clothed with water-repelling hairs beneath. A noticeable peculiarity of species of this genus is that they are full of some corroding acid that rusts and destroys the pins on which they are mounted in collections. On this account some collectors mount them on slips of paper, as is otherwise done only with minute insects.

E. Heeger writes of *D. clavigipes*, a European species, that the females, having passed the winter in water and under decaying vegetation, deposit their eggs one by one, in the daytime, upon the thick roots of the water plantain (*Alisma plantago*). Each female has only from forty to fifty eggs, which are deposited in from fourteen to eighteen days. In from ten to twenty days the larvæ appear, and feed upon the roots of the water-plantain. At the end of five or six weeks pupation takes place in a submerged, parchment-like cocoon, which is fastened to the stem of the water-plantain, and which the larvæ know how to fill with air. Pupation lasts from twenty to twenty-five days. Professor C. T. E. von Siebold states that the larvæ of *D. simplex* fasten themselves by the end of their abdomen in a hole which they gnaw out of the root-stalk of the bur-reed (*Spartanium simplex*), while they feed upon the diatoms and algae of the slime about them. The boring into the bur-reed is for respiratory purposes, the larvæ breathing the air of the intercellular spaces of the plant by means of its single pair of stigmata, which are in the hooks at the tip of the abdomen.

The CERAMBYCIDÆ, the so-called longicorn family, contains nearly as many species as does the family of Chrysomelidæ, and it is difficult to give any scientific characters by which to separate absolutely the two families, although collectors would rarely be in doubt as to which family to assign any given specimen. The species of Cerambycidae are generally somewhat elongated, often cylindrical. The antennæ are usually very long, sometimes much longer than the rest of the insect—whence the name longicorn. They are mostly filiform, in some cases serrate, imbricate, or pectinate.

rarely knobbed; they are inserted in various ways, and generally have eleven joints — sometimes more, rarely fewer; they are often much better developed in the males than in the females. The elytra usually cover the entire abdomen; a few genera, however, have very short elytra. The wings are absent in a few species, and the elytra comate. The mandibles are very stout, but of variable forms. The species are often beautifully colored, metallic or velvety, and are oftentimes of considerable size, the *Cerambycidae* probably containing the longest species of beetles. Many longicorns are more or less spiny, some species closely resembling twigs, and, according to Mr. H. W. Bates, *Ethomerus lacordairei*, a Brazilian species, mimics a butterfly's pupa grown over with fungus. A curious habit of *Megaderus bifasciatus*, a species found in Texas, is to eat out the printed portions of posters. Certain species are odorous, those of *Prionus* using their odor as a sexual attraction. *Callichroma moschata*, a large European species, derives its specific name from the pleasant musky odor which it exhales, and which is noticeable at considerable distance from the insect. Sonorific organs are possessed by nearly all, probably by all, species of *Cerambycidae*.

The eggs are laid in crevices of bark and of wood; the larvæ feed in both living and decayed wood. The females of a few species girdle twigs and lay their eggs in the portion beyond the girdling; the twigs thus girdled die and are broken off by winds, thus furnishing fresh but dead wood for the larvæ. The females of certain species are said to cut off or girdle twigs by seizing them in their mandibles and flying rapidly around the twig as a centre; this mode of girdling is exceptional, if practised by any species, since longicorns mostly girdle twigs while resting on the branch below the point to be girdled. Some species lay a large number of eggs; *Prionus laticollis* has been found, upon dissection, to contain from three hundred to six hundred eggs. The metamorphoses of some species of longicorns are supposed to require as long as twenty years, but if this is the case it is exceptional, for many species attain full growth in from one to three years.

The larvæ of *Cerambycidae* are long, cylindrical, or flattened whitish grubs, with distinct labial palpi, elliptical or circular stigmata, and Y-shaped anal opening. They bore, for the most part, in woody portions of trees; some, however, attack herbaceous plants. The head of the larvæ is partly retractile into the first thoracic segment, the antennæ are very small and concealed in a fold of the head, ocelli are usually absent. The larvæ are mostly legless, and when legs are present they are small, with only one claw; but the larvæ assist their peristaltic motion through their mines by means of wart-like processes upon their dorsal and ventral surfaces. The form and mode of plication of these processes are of importance in distinguishing the species of longicorn larvæ. Most of the damage done by these larvæ is in destroying timber or by killing shade trees, no less than a dozen different species being known to attack hickory. In Europe damage is said to have been done to grain by the larvæ of longicorns boring in the ears, and to vegetables such as carrots. The fleshy larvæ of *Macrotoma corticinum*, cooked with rice, are eaten by natives of Madagascar; and the natives about King George's Sound, in West Australia, eat both larvæ and imagoes of *Bardistus cibarius*.



FIG. 359. — Larva of *Monohammus*.

Cerambycidae are among the more difficult beetles to classify satisfactorily, because structural characters, which are usually generic, often become only of specific value in

this family. Three sub-families are easily recognizable; the highest, the Prioninae, have the prothorax margined and the labrum connate; the other two sub-families, the Cerambycinae and Lamiinae, have the labrum free and the prothorax without margin. The Lamiinae have, however, an oblique groove on the inner side of the front tibiae, while the front tibiae of the Cerambycinae are not grooved.

Of the Lamiinae, the genus *Saperda* is perhaps best known. The species are nearly cylindrical; the prothorax is cylindrical with no spines at sides. The elytra are a little wider than the prothorax, distinctly shouldered, and cover the entire abdomen and the well-developed wings. The legs are of moderate length, and are armed with claws which point outward at right angles to the tarsus. The claws are simple, except sometimes the outer one of the anterior and middle tarsi of males of certain species.



FIG. 360. — Longhorn beetles. a, *Saperda carcharias*, b, *S. populinae*, c, *Acanthocinus uditis*, male; d, female; e, *Lamia textor*.

Saperda birittata is from 0.55 to 0.75 of an inch long, is white beneath, with white face and antennae, and with two white longitudinal stripes above; the rest is light brown. It is found, in June and July, about apple, quince, mountain ash, thorn, shad-bush, and other rosaceous trees, in the wood of which its larvae feed. The beetle is nocturnal, remaining concealed by day and feeding by night, as is the case with all species of *Saperda*. The imago eats the leaves of the same kinds of trees of which the larvae eat the wood. The egg of *S. birittata* is laid in a cleft made by the female in the bark of the tree; after depositing it the female fills the cleft with a cement like secretion. The young larvae bore into the trees, and where numerous they do much damage to apple-trees. The larvae are legless, nearly cylindrical, the first segment behind the head being largest, the succeeding ones gradually narrower; the head is small, horny, and brownish. T. W. Harris writes that the larval state lasts two or three years, and that the larva penetrates during that time "eight or ten inches upwards in the trunk of the tree, its burrow at the end approaching to, and being only covered by the bark. Here its transformation takes place." Pupation lasts a month or two.

S. vestita, a species whose larva bores in linden and poplar, is from 0.5 to 0.8 of an inch long, is greenish yellow, with three black spots on the middle of each elytron. The beetles are found about the linden from May to the end of summer; they eat the bark and petioles of the leaves. In Philadelphia their larvæ have been at times so common as to do serious damage to the linden trees by penetrating the wood and undermining the bark. The larvæ are slender, of nearly the same breadth from the prothoracic region to the penultimate abdominal segment, and have three pairs of small



FIG. 361. — *Saperda tridentata*.

thoracic feet. *S. tridentata*, sometimes called *Compsidea tridentata*, is from 0.4 to 0.6 of an inch long, dark brown or gray in ground coloration, with dull red markings, as follows: a curved line behind the eyes, two stripes on the prothorax and a marginal, three-toothed, red stripe on each elytron. The legless larva, which feeds on the elm, is, according to Prof. A. S. Packard, "a little flattened, with the lateral fold of the body rather prominent; end of the body flattened, obtuse, and nearly as wide as at the first abdominal ring." The pro-

thoracic segment is wider than the rest of the larva. The whole larva is covered with scattered hairs. Oviposition takes place in June; the larvæ, after channelling beneath the bark, and furrowing the surface of the wood during one or more years, pupate in the spring. Not only do these insects attack dead trees, but they prove very destructive to living elms. In some cases the death of elms has been attributed to leakage of illuminating gas from the street mains, when in reality the cause of death was the boring of this destructive beetle. *S. lateralis*, which somewhat resembles *S. tridentata*, but in which the lateral line does not have three teeth, also mines the inner bark of elms. Its larva is similar to that of *S. tridentata*. Of other American species, *S. mæsta*, *S. calcarata*, *S. concolor* attack poplars. The last species is gray, with darker antennæ. *S. calcarata* is a large gray species, irregularly striped and spotted with yellow; it is sometimes 1.25 inches long. Its elytra end in a spur, whence its specific name. *S. mæsta*, a black species, about 0.35 of an inch long, is the only North American species found on the Pacific slope, being distributed from Canada to Oregon. In Europe two common species, both living on species of poplar, are *S. carcharias* and *S. populinea*. *S. populinea* is about 0.5 of an inch long, *S. carcharias* about double as long. The male of the latter species is grayish yellow, the female is ochre yellow. *S. populinea* is greenish or yellowish gray, with three longitudinal yellow lines on the prothorax and a longitudinal row of yellow spots upon each elytron.



FIG. 362. — Larva of *Saperda calcarata*.

Differing from the species of *Saperda*, in having cleft or appendiculate claws, are the species of the genera *Oberea*, *Tetraopes*, and *Phytoecia*. The species of *Oberea* are very slender, nearly cylindrical, and have the episterna of the metathorax wide, the epipleuræ distinct, and the claws broadly appendiculate. *O. tripunctata*, a species about 0.5 of an inch long, feeds as larva upon the stems of the raspberry. The beetle is black, with a yellow prothorax, on which are three black dots arranged in a triangle. It girdles the raspberry twigs in which it lays its eggs, probably in order to check the growth of the plant.

Tetraopes has a less slender form than *Oberea*, the claws are cleft, the eyes broadly divided, the prothorax dilated at the sides; the species are all bright red, marked with black spots, and all feed upon milkweed (*Asclepias*). The larvæ probably devour the



Acrocinus longimanus, Long-armed beetle.

roots of the same plants. *T. tetraphthalinus* has black legs and antennae, four black dots arranged in a square on the prothorax, and four spots of variable size on each elytron. In Europe species of related genera, *Phytocia* and *Agapanthia*, damage various wild and cultivated plants.

Oncideres has moderately divergent claws, angulated anterior and open middle coxae, and large front. *O. cingulatus*, a grayish-brown species, girdles and partly cuts off the twigs of hickory, pear, and other trees, in August and September, after having deposited eggs in the portion of the twig beyond the girdling. The winds of autumn break the twig from the trees, and the portion containing the eggs falls to the ground. The larvæ feed upon the wood of the fallen twig, — often when numerous reducing it to a mere shell of bark, — attain full growth the next summer, pupate and produce imagoes the following autumn, the whole transformations requiring only a year.

Pogonocherus is a genus of small longicorns, in which the front coxae are angulated, the middle coxae open, and the claws divaricate. The body and legs bear long hairs, and tufts of hair are found on the elytra. *P. mixtus* is one of the more common species, and feeds upon willow. It is about 0.3 of an inch long, and is mottled light and dark gray in color. Separated from *Pogonocherus* by the rounded anterior coxae are the species of *Acanthocinus*, of which *A. adilis*, from Europe, is figured. It appears early in spring, and oviposits on many kinds of trees. *A. obsoletus*, a mottled gray and black species, about 0.5 of an inch long, is not uncommon in the United States.

Acrocinus longimanus, which is common in tropical America, is a very curious and striking species of longicorn. The beetle is from 1 to 1.5 inches in length of body. It is remarkable both for its excessively long anterior legs, of which the femora and the tibiae are each equal to or longer than the body, and for having a large movable spine articulated upon each side of its prothorax. In coloration it is yellow, gray, and black, arranged in stripes of irregular pattern. It feeds upon the milky juice of *Ficus glabrata*, in the wood of which its large fleshy larva bores.

The species of *Monohammus* are large beetles having extremely long antennae, especially in the males. The fore-legs of the males are much elongated. The prothorax bears a strong lateral spine and the ventral segments are nearly equal in length. *M. confusor*, which is brownish gray with the elytra spotted with black and white, often reaches a length, exclusive of the antennae, of 1.4 inches. Its larvæ, as well as those of *M. scutellatus* and *M. marmoratus*, bore in pine wood, thus doing considerable damage to timber. Prof. A. S. Packard says of the footless larva of *M. confusor*. "Boring a hole, in outline round and regular, deep in the wood of sound, though usually in decaying, trees, and doing much injury to pine timber; a large, soft, white, fleshy, nearly cylindrical grub, the segment next the head larger than the others, flattened, horny, and inclined obliquely downward and forward, the succeeding rings very short, with a transverse oval rough space on the middle above and below, pupating inside in the wood, the beetle emerging from a round hole half an inch in diameter." *M. scutellatus*, mentioned above, is shining black spotted with white, and is very abundant about midsummer in the northern United States and in British America. It is somewhat smaller than *M. confusor*, measuring from 0.5 to 1 inch in length.

Closely related to *Monohammus* are the genera *Plectrodera* and *Ptychodes*. *Plectrodera scutator* is about 1.5 inches long, of robust form, and is shining black



FIG. 365.—*Tetranychus tetraphthalinus*; above, front view of head.

mottled with cream white. *Ptychodes vittatus* is slender, about an inch long, with very long antennæ and legs, and is of a rich brown ground color, with sutural and marginal stripes of white. Both the above-mentioned species are found in the south-western United States. In Europe a closely allied longicorn, *Lamia tector*, bores, in its larval state, in willow twigs. The beetle is from 1 to 1.25 inches long and nearly half as broad, of a dark brown color, with fine yellowish pubescence, through which glimmer little black points; its antennæ are about two-thirds as long as its body.

Pseuocerus supernotatus is a beetle only about 0.25 of an inch long, whose larva bores in the twigs of different kinds of currants. Its front coxal cavities are angulated, its prothorax is constricted behind and the humeral angles are distinct. The ground color of the beetle is black, the prothorax and margins of the elytra are pale brown, and there are a few white or gray spots on the elytra. Mr. William Saunders has well described the life-history of this species as follows: "Early in June the parent beetle of the native currant borer deposits her eggs upon the currant stalks, where they soon hatch into tiny grubs, which burrow into the heart of the stem and, feeding on its pith, reach full growth before the close of the season. They are footless grubs, which measure when full grown about half an inch in length. The head is scarcely half as broad as the body, is of a dark brown color, with black jaws. The body is whitish with some brown dots along each side, and is slightly clothed with very fine short hairs. When full grown and about to change to a chrysalis, the larva gnaws a channel through the woody fibre to the outer bark, so that when changed to a beetle it can make its escape by merely rupturing the bark. The cavity thus made is filled with little chips to prevent the bark from being prematurely broken, and below this stuffing the insect constructs a bed of short woody fibres, packing the passage below with a finer material resembling sawdust. Within this enclosure, which is about half an inch in length, the larva changes to a chrysalis and reposes until the fully formed beetle is ready to emerge; then, gradually drawing away the obstacles to its egress, it finds its way to the end of the passage, and gnawing a small round hole through the bark, effects its escape." As the larvæ remain in the twigs during the winter, an easy mode of destroying these longicorns is to break off the dead twigs in early spring and burn them.



FIG. 364.—a, *Clytus arietis*; b, *Necydalis major*; c, *Dorcadion cruz*.

Dorcadion is a well-represented genus in southern Europe. The humeral angles are not prominent, and wings are absent; the palpi are slender, the support of the labium distinctly visible, the antennæ not surpassing the body in length, and the prothorax with a spine on each side. *D. cruz* is velvety black, with silvery white markings in a cruciform arrangement as seen in the figure.

Turning our attention now from the Lamiinæ to the Cerambycinæ, we have to deal with longicorns which have marginless prothorax, palpi never acutely pointed, and the anterior tibiæ without grooves on the inner side.

The genus *Leptura* and some genera associated with it have the head distinctly narrowed behind the eyes to form a sort of neck; their front coxæ are conical; their eyes are nearly or quite round, not, as in many Cerambycidae, more or less enveloping the base of the

antennae; the stridulating plate on the mesonotum is divided by a smooth portion or by a furrow. These insects frequent flowers, seeming to prefer small flowers which grow in clusters, such as those of *Spiraea*.

According to LeConte and Horn's Classification of the Coleoptera of North America, from which work many of the anatomical characters of genera mentioned in this paper have been taken, the genus *Leptura* itself has acute mandibles fringed on the inner margin, long elytra, oblique or horizontal front, first joint of hind tarsi without brush-like sole, last ventral segment of the male not excavated, antennae without poriferous spaces, and hind coxae not contiguous. There are over seventy-five species of *Leptura* in North America, north of Mexico. Their larvae feed upon decaying wood. *L. canadensis* is dull brownish black with the anterior part of the elytra dull red, and the antennae yellow and black. It is about 0.6 of an inch long.

Tippocerus differs from *Leptura* in having large poriferous spaces on the antennae. *T. fugax*, a common species in the United States, has reddish brown elytra, each of which has four more or less prominent triangular yellow spots. The prothorax and body beneath are nearly black, densely clothed with yellow pubescence; the antennae are dull black, the legs reddish brown. Length about 0.5 of an inch.

Rhagium has the first joint of the posterior tarsi hairy beneath, and the prosternum prominent between the coxae. *R. lineatum*, the only North American species, is from 0.4 to 0.7 of an inch long, and is rusty gray, finely mottled with black. Each elytron has three slightly elevated longitudinal ridges, whence the name *lineatum*. The larva of *R. lineatum* is a flattened, yellowish-white, somewhat hairy grub, about an inch long. Its head is as large and as wide as its prothoracic segment; the mesothoracic and metathoracic segments equal in width the prothoracic segment, but are slightly wider than the abdominal segments. This larva is very common under the bark of pine logs, where it burrows about, and finally constructs a nest or cell in which to pupate. These cells, in which pupation takes place, are built of woody threads or fibres arranged in an oval ring between the wood and the loosened bark; the cell, which is usually a little over an inch in longest diameter, is lined with reddish bark-dust. The beetle emerges from the pupal state in autumn, but remains in its cell until the following spring, when it gnaws its way out; this is a somewhat exceptional mode of hibernation for Cerambycidae, most of which spend the winter as larvae. *R. mordax*, in Europe, copulate in April and May; the eggs are deposited in clefts of bark, the larvae reaching full growth and pupating the same year. Some of the European species of *Rhagium* attack, besides pine, the bark of birch and oak; *R. lineatum* thus far has been recorded only from conifers — from pine, spruce, fir, and hemlock. Remaining torpid as these beetles do throughout the winter, in their cells beneath the bark, they are particularly susceptible to the attacks of parasites: fungi kill a large number of them; others succumb to the attacks of mites (*Gamasus coleopterorum*), and specimens are not rarely found which are clothed with these parasites so as to hide the beetle entirely from view; and three species of Ichneumonidae and one of Braconidae are known to attack *R. indigator*, of Europe, a rather large number of hymenopterous parasites for a single species of beetle.

The genus *Neogubilis* is characterized sufficiently by its very short elytra, from beneath which the long wings always project, never being folded beneath the elytra, as is the case in the Staphylinidae, and in a few other genera of brachelytrous longicorns. Only three species are found in the United States, and their life history is not known. *N. major*, the species figured, is European.

Differing from the foregoing genera in having simple mandibles without fringes is the genus *Desmocerus*. *D. palliatus* is found about elder (*Sambucus*) when it is in blossom. This beetle is about 0.8 of an inch long, of a deep Prussian-blue color, except the anterior portion of the elytra, which is orange yellow. It is one of the most brilliant of our longicorn Coleoptera. Its larva bores in the pith of the elder. The females of *D. auripennis*, a species found on the Pacific coast, are dimorphic, the two forms being distinguished by different size of markings and by different fineness of punctuation.



FIG. 365. — *Desmocerus palliatus*.

Passing now to genera of the sub-family Cerambycinae that have the base of the antennae partly surrounded by the eyes, *Clytus* and related genera have long legs, finely granulated eyes, a rounded or broadly triangular scutellum, tibiae not carinated and with large spurs, prothorax never spiny or tuberculated, elytra not sinuate, and intercoxal process acute. The species are generally banded with yellow, white, or black, and are active both at flight and in running. *Clytus* in its limited sense, as defined by Drs. Le Conte and Horn, is confined in North America to two species, of which the life histories are unknown. *Clytus arietis*, a common yellow, black, and red European species which is figured on page 328, is found in its larval state in the dead wood of mulberry and sycamore trees, and in the living wood of some other trees. *C. sexguttatus*, also figured, is from Algiers.



FIG. 366. — *Clytus sexguttatus*.

Cyllene differs from *Clytus* in having the head proportionally smaller, the front short, the intercoxal process rounded, and the pronotum hollowed out at the sides of its base. *Cyllene robiniae* is very abundant upon locust trees, the wood of which is seriously damaged by its larvæ. The beetle is brownish black, figured beneath and transversely striped above with yellow, and has reddish legs. Almost all the figuration is produced by a coating of hair-like scales, the beetle being mostly black when these scales are removed. This beetle is quite common in autumn upon the blossoms of golden-rod (*Solidago*), the pollen of which it eats.



FIG. 367. — *Cyllene robiniae*.

In September the beetles may be seen, often in considerable number, running over the bark on the trunks of locust trees, copulating and ovipositing. The eggs are white, and are laid in crevices of the bark, five or six in a place. They hatch in a short time and the young larvæ eat a slight distance beneath the bark before winter comes on. The next spring they burrow about in the wood, throwing their refuse out of holes which they have made in the bark. Pupation takes place the latter part of July, and the beetles emerge in August and September; the entire metamorphosis of this species thus lasts only one year. *Cyllene pictus* is so nearly like *C. robiniae* that it has been confounded with it, oftentimes by good observers. *C. pictus* lives as larva, however, in hickory (*Carya*), the imago appears in June, and it has slenderer and shorter antennae than are those of *C. robiniae*.

Plagionotus speciosus has a form and style of marking similar to *C. robiniae*, but is larger and does not have the pronotum hollowed out at the sides. Its colors are deep black, and yellow. The beetle is found in July, when it lays its eggs in the

crevices of the bark of sugar maples, in which the larvæ bore. This species is not very abundant, and, although it now and then, perhaps, kills a very young maple, its ravages are not much to be feared. *Arhopalus* differs structurally from *Platynotus* in having filiform instead of compressed antennæ. *A. fulviventris*, the only North American species, is brownish black with fine grayish markings and dark brown legs; it has a conspicuous black spot on the pronotum, and the elytra are crossed by four fine indistinct zigzag lines of gray. Its larva bores in oak and chestnut wood.

In *Callichroma* the scutellum is acute at the tip, the anterior coxal cavities are closed behind, and the prothorax has a spine on each side. A common European species, *C. moschata*, of which the odor has been already alluded to, is about an inch long, bronze green with bluish green legs and antennæ. Its larva lives in willow. *C. splendendum*, a red-bronze species from 1 to 1.25 inches long, has been found in the southern United States.



FIG. 368. — *Platynotus spectans*.

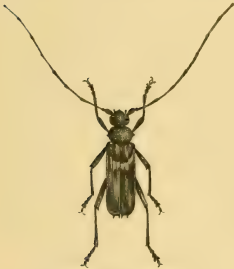


FIG. 369. — *Chion cinctus*.

The genus *Elaphidion* contains longicorns of medium or large size, with rounded thorax, moderately long, spiny antennæ, coarsely punctured eyes and often of clouded or rusty appearance on account of the unequal distribution of their pubescence. *E. parallelum* is one of the commoner species in the northeastern United States. It is about 0.6 of an inch long, and of an ashy brown color. The larva is a common borer in oak, and according to Prof. A. S. Packard, "may be recognized by the stout, thick thoracic feet, by the rather small prothoracic segment compared with the two hinder ones, by the absence of the ligula, by the large well-developed palpi and antennæ, and by the shape of the callosities." I have found the larva of this species to be very injurious to the hickory in northern Connecticut, where it eats away the

wood beneath the bark of twigs up to an inch in diameter, causing the twigs to fall in winter, when the larva continues feeding in the fallen portion. The larva of *Catogenus rufus*, a beetle belonging to the Cucujidæ and common in the same region, devours pupæ of *E. parallelum*. *Chion cinctus* resembles an *Elaphidion* in general aspect, except that the prothorax of *Chion* has a short spine on each side, and its scutellum is triangular instead of rounded behind. In *C. cinctus* the scutellum is whitish, and there is an irregular yellowish band partly across each elytron just forward of the middle. The larva feeds in hickory.

Cerambyx heros, a not uncommon brownish-black beetle in Europe, is from 1 to 1.6 inches long, with antennæ about equal in length to the body. Its prothorax is plicate above, and armed on each side with a spine. Its large fleshy white larva feeds in the wood of oaks, the beetle requiring two



FIG. 370. — Larva and pupa of *Chion cinctus*.

years for its metamorphoses. The beetles frequent the leaves of oaks, appearing during June in France.

To the genus *Callidium*, in its less restricted sense, belong flattened species of longicorns with prothorax and elytra spineless, with eyes not embracing the base of the antennae, and having the femora usually much thickened. Some of the species of this genus are very variable; *C. variabile*, a species common both in Europe and America, has over twenty well-defined varieties. It is often entirely brownish yellow, sometimes the prothorax only is brownish or reddish yellow, while the rest of the beetle is deep blue. Its larva feeds in oak. *C. antennatum*, of the United States, and *C. violaceum*, of Europe, are both entirely of a very deep metallic-blue color.

Both feed, as larvæ, upon conifers.

Hylotrupes bajulus is similar in form to *Callidium*, but has a broader prosternum. Its prothorax is nearly round. The entire beetle is usually black, clothed in places, especially on the prothorax and elytra, with ashy pubescence, but sometimes the elytra are brownish yellow. Its length is about 0.75 of an inch. The larvæ eat the wood of conifers, and, according to

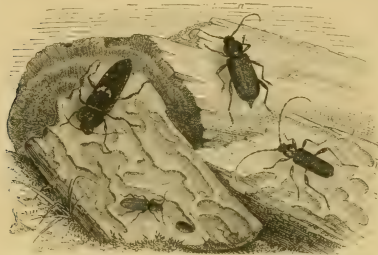


FIG. 371. — a, *Callidium violaceum*; b, *C. variabile*; c, *Hylotrupes bajulus*.

Kirby and Spence, have done much damage to rafters and roofs in London; when the beetles arrive at maturity they even pierce sheets of lead to escape from the wood. This species is found near the coast in North and South America, where it has been introduced from Europe. *Asemum moestum*, an American species, is similar in form to *H. bajulus*, but is somewhat smaller and of a dull, dark brown color. Its larva bores in pine wood.

The last sub-family of the longicorns, the Prioninæ, which have a margined prothorax, are mostly insects of considerable size, with strong jaws. In some species, of which *Macrotoma lethifer* is an example, the males are eight or ten times more numerous than the females, and fight among themselves for the possession of the females. In these fights the males bite off one another's antennæ and legs. In *Prionus* sexual activity is very great, the male being attracted to the female by her odor, and apparently, on the other hand, the males are attractive to the females by the same means. Copulation, as observed in *P. coriarius*, lasts scarcely two minutes.



FIG. 372. — *Prionus laticollis* and pupa.

The species of *Prionus* have three teeth upon each side of the prothorax, the antennæ are imbricated; in *P. imbricornis* the imbrication is beautifully exhibited. The antennæ have, in American species of *Prionus*, from twelve to twenty-seven joints. *P. laticollis*, one of the common North American species, is from 0.75 to 1 inch in length, brownish black in color, and both male and female have twelve-jointed antennæ. In *P. imbricornis* the joints of the antennæ of the male vary from eighteen



FIG. 373. — a, *Prionus coriarius*, and b, *Ergates fuber*.

to twenty, while those of the female have from sixteen to seventeen joints. The males sometimes have a different number of joints in the right and left antennæ. The fleshy white larvæ of *P. laticollis* bore in the roots of various plants, among which may be especially mentioned grape, apple, poplar, and pine. In Europe, *P. coriarius* is the common species; its larva feeds in the wood of oak, birch, beech, and pine. Its eggs, which are deposited, two to eight or more in the same place, are fusiform cylindrical, from 0.16 to 0.20 of an inch long, and 0.04 to 0.05 of an inch in diameter. The eggs hatch in about thirty-seven days, the young larvæ eating the bark of the tree on which the eggs are laid.

Orthosoma brunneum (sometimes called *O. cylindricum*), a more elongated species than those of *Prionus*, is found in the eastern United States. It is from 1.25 to 1.75 inches long, of light-brown color, and has eleven-jointed antennæ. Its large fleshy larva, which resembles that of *Prionus*, bores in rotten stumps of pine, oak, and hemlock.

A large pitch-brown European species of *Prioninae*, *Ergates fuber*, from 1.25 to 2 inches long, feeds, in the larval state, upon pine wood.



FIG. 374. — *Orthosoma brunneum*.

Parandra brunnea, the fleshy, cerambycid-like larva of which is an inhabitant of dead oak, ash, and beech wood, is from 0.50 to 0.75 of an inch long, of a shining mahogany-brown color, and elongate form. It has antennæ less than 0.20 of an inch long, and adult structure otherwise anomalous for a longicorn, and has consequently been put by some authors, with other anomalous allies, into the family Spondyliidæ.

A large number of beetles of which the head is more or less prolonged anteriorly into a beak, and of which the larvæ have considerable resemblance to one another, were, for a long time, included in one large family, the Curculionidæ; the popular name for these insects is "weevils." Later the Curculionidæ were divided by different authors in various ways into families, the name Curculionidæ being retained for the forms having the most typically beak-formed head, while the families Bruchidæ, Anthribidæ, Brenthidæ, and Scolytidæ were separated from the rest. Later still, about 1874, Dr. J. L. Le Conte constituted of the weevils, excluding the Bruchidæ, a separate group of Coleoptera, the Rhynchophora, which was sub-divided into families. Dr. Le Conte's definition reads as follows: "Rhynchoporous Coleoptera are those in



FIG. 375. — a, *Bruchus pisi*; b, *B. rufimanus*; c, *B. granarius*

which the posterior lateral elements of the head and prothorax coalesce on the median line of the under surface of the body, so as to unite by a single suture." The Bruchidæ, a group of seed-inhabiting weevils, were excluded from the Rhynchophora and placed near the Chrysomelidæ.

In the following pages the weevils, or old family Curculionidæ, will be treated under the families Bruchidæ, Anthribidæ, Brenthidæ, Scolytidæ, and Curculionidæ.

The BRUCHIDÆ consist of rather small, roundish or subquadrate beetles, having the anterior part of the head slightly extended, the mentum pedunculate, the prosternum reaching the posterior margin of the thorax beneath, the antennæ eleven-jointed and thickened toward the tip, and the maxillary palpi four-jointed. The larvæ of Bruchidæ do much damage to the seeds of leguminous plants. The perfect beetles appear when the plants are in bloom, lay their eggs, generally one by one, in the tender seeds or upon the young pod. The larvæ, as soon as they hatch from the eggs, bore in the seed, not, however, preventing its growth. Pupation takes place in the seed, and the perfect insect emerges in autumn or the succeeding spring, according to climate and circumstances. Dr. J. L. Le Conte has well said that "as the function of the Cerambycidæ is to hold the vegetable world in check by destroying woody fibre, the Bru-

chidae effect a similar result by attacking the seeds, and the Chrysomelidae by destroying the leaves."

One of the most widely known species of Bruchidae is *Bruchus pisi*, the pea-weevil, found both in Europe and in America. This beetle is about 0.20 of an inch long and 0.12 of an inch wide, is dark brown with a few white spots on the elytra and a slightly more prominent white spot just in front of the white scutellum. The tip of the abdomen, which projects beyond the apices of the elytra bears a T-shaped white mark. The females fasten their lemon-yellow, sub-cylindrical eggs with a gummy secretion upon the outer surface of the newly formed pod of the pea. The white, footless larvae, when they hatch, bore through the pod into the developing seed within, where they continue to grow with the pea itself. In eating green peas we eat, oftentimes, large numbers of these young larvae, a very minute dot on the surface of a pea being the only external evidence of the presence of a weevil larva within. The peas that are collected one season for next year's seed often contain a large number of these insects, which escape as imago the next spring, when the peas are planted, and deposit eggs for a succeeding generation. United effort on the part of those who cultivate peas would do much to lessen the number and destructiveness of these weevils. Seed peas should be kept in bags made of tightly woven cloth from which the weevils cannot escape, and the beetles should be killed before the peas are planted by immersing the bags for a moment in hot water, which process will not impair the germinating power of the seeds; or weevils may be destroyed by putting seed peas into a close box and adding a little carbon disulphide. On account of the explosiveness of the vapor of carbon disulphide this mode of treatment should be used only in the absence of fire or lighted lamps. Some persons keep seed peas, after they have dried sufficiently to prevent moulding, in close vessels for two years, at the end of which time the peas will have lost very little of their germinative vitality, while the weevils will have emerged and died during the first year. Peas sown late in the season are not attacked by these weevils, because they blossom after the time during which these insects oviposit. The Baltimore oriole (*Icterus baltimore*) splits open the pods of peas to get at the larvae of the pea-weevil, and the crow-blackbird (*Quiscalus purpuraceus*) is said to eat the imago in the spring, but these weevils mostly escape the attention of other birds.

Bruchus fabae is another common American species, much smaller than *B. pisi*, which attacks different kinds of beans, several beetles sometimes emerging from a single bean, while each *B. pisi* usually occupies a pea by itself. In Europe two similar species, *B. granarius* and *B. rufimanus*, are destructive both to beans and to peas.

Differing from *Bruchus* in having the anterior coxae separated by the prosternum are the species of *Caryoborus*. *C. arthriticus* is an ashy-brown species, about 0.4 of an inch long, from the southern United States, where its larvae develop in the seeds of the palmetto (*Subal palmetto*).

The ANTHRIDIDE are weevils, characterized, according to Dr. J. L. Le Conte, by having the abdomen of the male and female alike; i. e., composed of the same number of segments, the elytra with a distinct lateral fold on the inner surface, a vertical pygidium, — or distal end of the abdomen, — and straight antennae.

Cratoparis lunatus, the commonest species of Anthribidae in the eastern United States, is about 0.3 of an inch long; its ground color is dark brown; the upper half of the head and forward part of the prothorax are cream-white, and an irregular spot near the middle of each elytron is of the same color; the rest of the insect is

finely spotted with cream-white and with black. This beetle is found in species of fungus which grow upon trunks of dead trees.

Larvæ of species of *Brachytarsus*, another anthribid genus, are parasitic in the females of different kinds of Coccidæ, where they eat the eggs of the scale-insects. This is an exceptional mode of life for weevil larvæ; the majority of them feed upon vegetable matter.

The BRENTHIDÆ are very elongated weevils, probably the most elongated, proportionately, of all beetles. *Brenthius anchicago*, of tropical America as far north as Florida, is about 1.40 inches long and only 0.12 of an inch wide at its broadest part. Still more peculiar than their extreme attenuation is the secondary sexual characters of their mouth-parts to accord with their functions. In *Eupsalis*, which differs from *Brenthius* in having a convex thorax without grooves, the female has a prolonged proboscis, with the mandibles at its tip, as is common among weevils; with this proboscis she bores holes into the bark of the trees which are to furnish food for the larvæ, and in each hole she deposits an egg. The male, having no such work to perform, has no proboscis, but is provided with strong, curved mandibles of the ordinary type found in beetles. The males have combats for the possession of the females; and, although they cannot injure one another on account of their hard chitinous shells, sooner or later one of the combatants withdraws, tired of the battle, leaving the other in possession of the female. While the female is occupied in boring a hole for an egg, an operation which takes about a day, the male guards her and strives to drive away any other males that approach. Mr. A. R. Wallace says of the Brenthidæ, that it is interesting, "as bearing on the question of sexual selection, that in this case, as in the stag-beetles, where the males fight together, they should be not only better armed, but also much larger than the females."



FIG. 356. — *Eupsalis minuta*.

Eupsalis minuta is distributed throughout the eastern United States and Canada, although most of the Brenthidæ are confined to the tropics. It is shining mahogany-brown, with fine yellow spots on the elytra, and is very variable in size, males sometimes measuring over 0.75 of an inch long, while females are now and then found that are not over 0.25 of an inch long. The elongated larvæ of *E. minuta*, which has been described by Dr. C. V. Riley, inhabits decaying oak wood, around which the beetles are not rare.

The SCOLYTIDÆ are small beetles, some of them almost microscopic, all having a similar general aspect and a nearly cylindrical form, and are, for the most part, of a brown color. The head is usually short, and imbedded in the anterior end of the prothorax; the proboscis is short, often not apparent; the antennæ are small, geniculate, clubbed; the tibiæ are usually serrate; the horizontal pygidium is undivided in both sexes, and is surrounded at its edge by the elytra. Both the mature beetles and their larvæ bore in plants, usually trees, on which they feed, often between the bark and wood, — more accurately speaking in the liber, — and their channels, revealed by pulling off the bark, exhibit many curious forms characteristic of the species or genera of Scolytidæ to which they pertain. These beetles are especially destructive to Conifera; some species attack other trees, and a few injure herbaceous plants.

The peculiar forms taken by the mines of these beetles in wood and bark are dependent upon the mode of oviposition of the different species. The males form chambers ("Rammelkammer" of K. Lindemann) in the bark, in which they await the females. After pairing, the females enlarge and prolong this copulation-chamber,

making passages out from it. The eggs are laid singly in separate niches, which the females gnaw out at regular intervals along the sides of these radiating passages. According to Lindemann, if only one female comes to the male in his copulation-chamber, then only one radiating passage is made along which to lay eggs, but if more than one female comes to the same male, then each female makes a radiating passage from the single copulation-chamber. Each larva, when it hatches, eats out more or less at right angles to the radiating passages, increasing the size of its mine to accommodate its increased growth. The different larvae, all boring out from a common centre or channel, each species in a way peculiar to itself, produce remarkable foliate or dendriform figures, which are modified by the number of radiating channels, a number dependent upon the number of females that came to the male which originally established the colony.

The larvae of Scolytidae are legless, cylindrical grubs; locomotion is effected by fleshy warts which replace the legs. These larvae have no ocelli, and very short concealed antennae; they pupate beneath bark or concealed in plants, and thus their whole transformations are undergone out of reach of all birds except woodpeckers. The beetles themselves are nocturnal, thus escaping insectivorous birds. Besides the wood-boring habits of the Scolytidae, which render them especially destructive to forests, the imago of some species eat the buds of conifers to such an extent as to kill the trees. Some entomological writers, however, claim that the Scolytidae attack only dead or dying trees. The North American Scolytidae number about one hundred and forty described species, of which the specific characters are minute, and of which only a few of the best-known species need be mentioned here.

The species of *Dendroctonus* are rather large, cylindrical, with five joints in the funicle of the antennae, that is, in the portion between the basal joint, — often called the scape, — and the club or dilated end of the antennae. *D. terebrans*, a species about 0.3 of an inch long, and common throughout the United States and Canada, feeds in pine. *Hylurgus piniperda*, a nearly allied species, attacking all kinds of pine in Europe, possesses, in both sexes, sonoric apparatus, consisting of two corrugated organs on the abdominal segments, which produce noise by rubbing against corresponding portions of the elytra.

Hylesinus includes species in which the funicle of the antennae is composed of seven joints, and nearly or quite equals the club in length. Most of the species are clothed with flat scales. *H. trifolii*, a species that, in Europe, has done much damage by boring in the roots of clover and medic (*Medicago sativa*), has been found in the eastern United States seriously injuring the clover crops. The beetles are about 0.1 of an inch long. They pair in early spring, and, after pairing, the female gnaws a cavity in the top of roots of two-years-old clover, wherein she deposits from four to six white elliptical eggs. The larvae, as soon as they are hatched, bore along the axes of the roots of the clover, causing the plants to weaken, and often to die. Sometimes as many as sixteen specimens are taken in a single clover root. Hibernation takes place as larva, pupa, or imago. No mode of successfully combating this enemy of clover crops has been devised. A number of European species of *Hylesinus* attack pine, others, ash, poplar, or ivy (*Hedera helix*). *H. aculeatus*, of North America, depredates on ash.

In *Scolytus*, "the side margin of the prothorax is distinctly defined, a very rare



FIG. 377. — *Dendroctonus terebrans*.

character in Rhynchophora," and "the first joint of the funicle rounded, the remaining joints (five in number) closely united, forming a pedicel to the club." *S. quadrispinosus*, having deep striæ, and the male of which has a spiny abdomen, has been bred by Dr. C. V. Riley from hickory (*Carya*); its length is about 0.2 of an inch. *S. fagi*, another deeply striate species, of which neither males or females have a spiny abdomen, is about 0.2 of an inch long, and was bred by Mr. B. D. Walsh from beech (*Fagus*). *S. rugulosus*, a species lately introduced from Europe into the eastern United States, attacks cherry, peach, and plum trees; and, as is so often the case with imported insects, does more damage in its adopted country than it did in its native land.

The CURCULIONIDÆ, the true weevils, are generally compact beetles, of firm structure, often having elytra so hard as to be penetrated with difficulty by an insect pin, and are provided with a proboscis pointing forward and downward, produced, as in other weevils, by the anterior prolongation of the head, and bearing upon its sides the antennæ, which are straight in some sub-families, geniculate in others. The mouth-parts, mostly somewhat abortive, are at the end of the proboscis; the labrum is wanting in many species. The ventral segments are five in number, although the first and second are often more or less united, frequently to such an extent as to partly obliterate the suture. In some sub-families the sexes are distinguished by the presence in the males of an additional anal segment; in certain species the females have a longer proboscis than the males, the proboscis being used in boring holes in which to lay eggs. Many species can produce creaking sounds, by rubbing the abdominal segments against the inner surface of the elytra.



FIG. 378. — *Bolaninus nutum*; side of head beneath.

The Curculionidæ are remarkable for the great diversity of mode in their ornamentation; pubescence, punctate and striate surfaces, alone or in combination, highly polished or excessively warty surfaces, surfaces clothed with pollen-like waxy secretions (as in *Lixus*), all modes of ornamentation common to most families of Coleoptera, are aided in many species of Curculionidæ by scales, which often surpass in brilliancy those that furnish material for the color-patterns on the wings of Lepidoptera. Especially resplendent under the microscope are the scales of the diamond-weevils (species of *Eutimus*) from South America; of species of *Chlorophanus* and *Polydrosus* from Europe, and of species of *Evophthalmus* and *Eudagogus* from warmer parts of North America. The larvæ of Curculionidæ are short, cylindrical grubs, mostly legless or with very rudimentary legs. A few have ocelli.

With very few exceptions, species of Curculionidæ are phytophagic; one species, *Evirrhinus infirmus*, is said to have been reared from the bodies of dead insects. Scarcely any portion of plants escapes injury by larvæ of weevils; many species live in seeds, in grain, in nuts, in rolled-up leaves, in catkins, in fruit; others bore in wood or pith; others feed exposed upon leaves or mine in their parenchyma; a few make galls or gall-like excrescences upon stems or roots, while a number have been observed to feed in plant-galls made by hymenopterous insects; a few breed in fungi. Weevils are found in all kinds of situations; eyeless species live in caverns or subterraneously;

one species, at least, *Phytobius relatus*, rarely seen on water plants both in Europe and America, can swim fairly well. Of another species, *Lissorhoptrus simplex*, which attacks rice in the eastern United States, Dr. C. V. Riley writes, "The beetle is just as much at home under water as out of it, though not surrounded by an air-bubble, as in Hydrophilidæ, Elmidae, *Psephenus*, and others."

A large number of adult weevils imitate their usual surroundings, bark, leaf-buds, and other parts of plants, so successfully that they are well protected from attacks of birds. In their earlier stages most of them are hidden, and the pupæ of some (e. g. *Cionus*) that pupate in exposed situations so closely resemble seed-pods of the plant on which the larvæ feed that they are not molested by birds.

Guibourt, in 1858, called attention to a sugar which figures in the materia medica of Persia, under a name meaning nest-sugar, which is obtained from swellings, as large as olives, that are produced by a species of *Larinus* upon a plant of the genus *Echinops*, in Syria. According to Haubury, another species of *Larinus* from the same region makes a cocoon containing saccharine matter.

The number of described species of Curculionidæ exceeds ten thousand. This family is here divided into sub-families, which correspond in limitations and characters to the similarly designated families in Le Conte and Horn's Rhynchophora of America north of Mexico.

To the sub-family Apioninæ belong those species which have straight antennæ, the abdomen of the male and female alike, horizontal pygidium, and the elytra with a lateral fold on the inner surface. Most of the species are quite small.

Apion, the typical genus of this sub-family, is well represented in North America, but the species are not yet carefully studied. Many of these little weevils feed in seeds. In America *A. rostrum* feeds in seeds of *Baptisia leucantha*; *A. squipies* in seeds of *Tephrosia virginica* and of *Astragalus*. In Europe, Heeger found the larvæ of *A. eucirostre* in the stem of mallow (*Malva*). The females, after pairing several days with different males, lay their eggs, to the number of fifty or sixty, in holes which they bore into the stem of the mallow. The larvæ attain full growth in from thirty to forty days, the beetles develop in from ten to fourteen days more, and gnaw their way out of the stems.

The sub-family Calandrinæ contains species which have a steep or vertical pygidium, and geniculate, clubbed antennæ. The species range from very large to very small weevils.

Three species of the genus *Calandra* are distributed in North America, two of which have been introduced from Europe. They are small, and have an oval antennal club. *C. granaria* is a pitchy red weevil about 0.12 of an inch long. The striate elytra do not reach the tip of the abdomen; the coarsely punctured thorax is nearly half as long as the whole insect. The females lay their eggs on stored grain, in which the larvæ feed. By rapid multiplication and immense numbers they sometimes do great damage to grain in store. *C. oryza*, a beetle similar in form to the preceding species, but a trifle smaller, being generally about 0.1 of an inch long, differs from it also in having one or two large red spots on each elytron. It attacks rice, wheat, and corn (*Zea mays*), ovipositing on rice while growing. This beetle is said to have been distributed by commerce to nearly every part of the world. The other North American species of *Calandra*, *C. remotepunctata*, resembles *C. granaria*, but has much more coarsely striated elytra. Like the introduced species of the genus, *C. remotepunctata* feeds on grain.

Species of *Sphenophorus* are larger than those of *Calandra*, and have a wedge-shaped antennal club. Their general form is similar to that of *Calandra*, although the prothorax is not quite as large proportionally. The species of *Sphenophorus* are not easily distinguished. Several of them have been found to injure corn by eating into the young plants and leaves just after they come up out of the ground, and Mr. L. O. Howard found the larvæ of *S. robustus* boring in the pith of cornstalks near the ground.

Rhynchophorus is the genus in which are included the large palm-weevils; its species are distinguished from the other Calandrinae by having wide side-pieces of the metathorax. *R. ferrugineus*, which is figured, is the well-known Javan palm-borer, found throughout the East Indies. *R. cruentatus* is common in the southern United States, where it feeds upon the palmetto. It is about 1.25 inches long, of a deep shining black, marked with mahogany-red. Its form is similar to *R. ferrugineus*. *R. palmarum*, of similar general appearance to *R. ferrugineus*, has been taken in southern California, although its regular habitat is further to the south in tropical America. The large, fleshy, white larvæ of the three above-mentioned species of *Rhynchophorus* bore in the stems of palms; and Kirby and Spence write as follows of them:—"Ælian speaks of an Indian king, who, for a dessert, instead of fruit set before his Grecian guests a roasted worm taken from a plant, probably the larvæ of this insect, which he says the Indians esteem very delicious,—a character that was confirmed by some of the Greeks who tasted it. Madame Merian has figured one of these larvæ, and says that the natives of Surinam roast and eat them as something exquisite. A friend of mine, who has resided a good deal in the West Indies, where the palm-grub is called *grugru*, informs me that the late Sir John La Forey, who was somewhat of an epicure, was extremely

fond of it when properly cooked." In Demarara a species of *Rhynchophorus* attacks the sugar-cane.

The largest sub-family of the Curculionidæ is the Curculioninæ, which contains weevils in which the male has an appended anal segment more than the female possesses; in which each elytron has an acute lateral fold on the inner surface; in which the antennæ have a solid or annulated club, the tarsi are dilated, and the usually pincer-shaped mandibles are without a scar, that, in the next sub-family, Otiorhynchinæ, is caused by the falling off of an appended mandibular piece.

Balaninus is readily distinguished from all other weevils, in fact from all other Coleoptera, by having mandibles that move vertically; each of these mandibles, which are at the tip of a slender proboscis, has its condyle and consequently its axis of motion on its upper side. Sometimes the proboscis is longer than the body, not rarely twice as long as the body in females, since they use it to bore holes in which to oviposit. As these holes are bored in nuts having very thick husks, the proboscis of the female must be correspondingly long. Few persons have failed to notice the so-called worms in chestnuts. These worms, when in American chestnuts, are the footless



FIG. 379.—*Rhynchophorus ferrugineus*.



FIG. 380.—*Balaninus nasicus*.

larvæ, or grubs, of *B. caryatipes*. They reach full growth when the chestnut ripens, and then gnaw their way out of the nut in order to pupate in the ground. Some of the beetles appear the same autumn, and hibernate as imago; others, probably the larger number, appear the succeeding spring. The beetle itself is dark brown, densely covered with yellow compressed hairs, which are somewhat irregularly distributed in spots upon the elytra. Its length is about 0.3 of an inch. *B. masicus* lives in hickory nuts, and *B. rectus* in acorns; both species have a close resemblance to *B. caryatipes*, and also to *B. mucronatus*, the European species figured, which attacks both acorns and hazel nuts. The larva of *B. villosus*, another European species, feeds upon the inner portions of the apple-formed galls of *Cynips terminalis*, on oak.

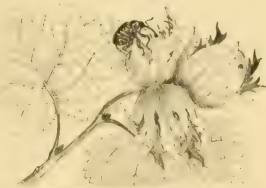


FIG. 381. — *Balaninus mucronatus*.

Trichobaris trinotata, a black weevil about 0.2 of an inch long, receives its specific name from three impressed, shining black spots near the base of the prothorax. It is common in the middle and western United States, where its larva is a serious potato-pest. The female weevil oviposits in oblong slits which she bores in the stems of the potato, and the larvæ, upon hatching, penetrate downward toward the root of the plant, causing its death. The larva is a legless white grub. It pupates in the stem of the potato, the beetle emerging about the beginning of September.

A small weevil that causes considerable injury to grapes is *Craponius inaequalis*. This insect is only about 0.1 of an inch long, of broad, almost circular, outline, grayish black, the elytra striate with large punctures; the legs reddish. In June and July this species lays its eggs in grapes, causing a change of color of the berry near the point of puncture. In August the larvæ drop to the ground, in which they pupate, the beetle emerging the next month.

Analcis fragaria is about 0.15 of an inch long, of a deep chestnut brown, with the elytra slightly lighter colored; the thorax is deeply punctured. The female oviposits in the crown of strawberry plants, and the larvæ bore down into the strawberry root. *A. foreolatum*, a black species with yellowish spots, is abundant upon the evening-primrose (*Oenothera biennis*).



FIG. 382. — *Conotrachelus nenuphar*.

Probably the weevil most injurious to agricultural interests in America is the so-called plum-weevil, or plum-curculio, *Conotrachelus nenuphar*. This beetle is oblong-oval, about 0.18 of an inch long; dark brown, spotted in places with black, yellow, and white. The head is small, and when at rest is drawn back so that the eyes are nearly hidden by the forward edge of the prothorax, and the proboscis is received into a groove on the chest. The elytra bear interrupted ridges, and cover the entire abdomen.

Beneath, the sutures are curved, the coxæ are contiguous, the thighs bidentate, and the claws divergent and toothed. This species is distributed throughout the Atlantic slope of North America. It hibernates as imago, and when the plums, cherries, and other stone-fruit begin to develop in the spring, the female

makes punctures with her proboscis, — which, as in most weevils, is functionally an ovipositor, — just beneath the skin of the fruit, and deposits an egg in each puncture. When the female has thus oviposited, she makes a crescent-formed cut in the surface of the fruit about the egg, so that the egg itself remains in a sort of flap. The footless, fleshy, white larvæ, which hatch from the white eggs in from four to eight days, bore into the fruit, where they eat the fleshy portion just around the stone. The larval state lasts from three to five weeks. The disturbance made by the larva generally causes stone-fruit to fall to the ground; there the larva, as soon as full-grown, deserts the fruit in order to pupate a few inches beneath the surface of the ground. The full-grown larva is about 0.4 of an inch in length, yellowish-white with a light brown head, and is legless. Pupation lasts about three weeks, when the beetles emerge, hibernating later beneath leaves, under bark, and in other secluded nooks. This weevil is said by Dr. C. V. Riley to attack the fruit of “the nectarine, plum, apricot, peach, cherry, apple, pear, and quince, preferring them in the order of their naming.” The remedies that thus far seem best in order to lessen the numbers of the plum-weevil are to destroy the fruit that has fallen to the ground, and to capture the beetles by jarring the trees. Of course an application of the first remedy will not give any visible result the first year, because only larvæ will be destroyed, but the beetles will be less numerous succeeding years, and if all fruit-culturists would unite in thus destroying these weevil-larvæ in the fruit, their injuries would rapidly decrease. Fallen fruit, containing these and other larvæ, can be gathered, carted from the orchards, and destroyed; but often a much more convenient and profitable way is to let hogs into the orchards, where they can eat the fruit promptly as it drops from the trees. The capture of the beetles by jarring them from the trees depends upon the habit which nearly all weevils, in common with many other insects, have of dropping to the ground when suddenly disturbed. Dr. Hull, an Illinois fruit-grower, has contrived an apparatus for capturing the weevils by jarring. This apparatus is, essentially, a large white umbrella inverted over a wheelbarrow. Into that side of the umbrella which is directly opposite the person pushing the barrow a slot extends nearly to the middle, where, upon the front end of the wheelbarrow, a pad is fastened to prevent bruising the trees. The wheelbarrow is pushed suddenly against the trunk of each tree, the slot admitting the trunk, and allowing the umbrella to pass beneath the tree, and the jar which the tree receives from the padded barrow shakes the weevils into the inverted umbrella below.

Passing now from a species especially noteworthy for the agriculturist, the next species to be considered, *Cionus scrophularia*, attacks plants of little value to man, but is interesting to naturalists on account of its peculiar mode of life. The beetle itself, which is common in Europe, and has been taken in America, is nearly globular in form, and about 0.15 of an inch long. Its elytra are dark gray, spotted with black and white, its prothorax yellowish-white; beneath, the abdomen is black, the legs and anterior portions gray; on the elytral suture, a little in front of the middle, is a black spot. The species commonly inhabits *Scrophularia nodosa*, although often feeding on other plants. Its larva feeds exposed upon the leaves of the plant, and covers itself with a sticky secretion which is discharged from a wart upon the basis of the twelfth segment, and which enables it to adhere to the leaves. When ready for pupation, the larva spins a parchment-like cocoon with its secretion. This cocoon is wonderfully similar to the seed-capsules of the *Scrophularia*, and is generally attached to pedicels of these seed-pods. This is a most striking case where a cocoon mimics, for

protection, a part of a plant. The larvæ and cocoons of *Phytonomus*, of *Phytobius*, and of a few other genera of weevils are not greatly unlike those of *Cionus*. *C. scrophulariæ* remains in the pupal state only from six to eight days; it escapes from its chrysalis by cutting a round lid out of one end of the cocoon.

Anthrenomus quadrigibbus is a reddish-brown weevil, from 0.12 to 0.20 of an inch long, having a proboscis in the female longer and in the male shorter than the body; this species, which is found in the eastern United States, is easily recognized by its having two protuberances, one behind the other, near the tip of each elytron. Its larvæ feed in apples, pupation taking place within the fruit.

The genus *Liens* includes rather elongated weevils, in some of which the tips of the elytra are prolonged into a spine. The species are usually covered with a yellow or reddish pollen-like powder, which is easily rubbed off. *L. concavus*, a common species in parts of the eastern United States, is found upon a kind of dock (*Rumex orbiculatus*); its length is 0.6 of an inch, and it has spineless elytra.

Pissodes strobi, the three states of which are sufficiently recognizable from the illustrations, is



FIG. 383. — *Pissodes strobi*: larva, pupa, and adult.



FIG. 384. — *Hylobius pales*.

about 0.3 of an inch long, and is dark brown, spotted with white. It inhabits the eastern United States, where its larva attacks the leading shoots of young pines. In Europe five species of *Pissodes* are known to attack pine. Quite closely related, systematically, to *Pissodes*, but larger (0.27 to 0.40 of an inch), and dark brown, with a few scattered yellowish dots, is *Hylobius pales*; this species is found in the same regions as *P. strobi*, and, like it, attacks pines.

Phytonomus punctatus, probably introduced into America from Europe, where its food habits and life history had not been carefully recorded, has become, in parts of New York state, an important clover insect. It is an oval beetle, about 0.4 of an inch long, with short proboscis; its ground color is dark brown; the sides of the elytra, and often the elytral suture, are lighter brown, as are also three longitudinal lines on the smooth thorax. The elytra are punctate in lines. The eggs of this species are oblong, yellow, and are deposited in clusters in the hollow stems or other parts of clover plants. The larvæ hatch in about ten days; they are yellowish white at hatching, but become greenish as they approach full growth. They are legless, but travel upon the stems and leaves of the clover by means of fleshy tubercles upon their ventral side, aided by a gland in the anal region, which secretes a sticky fluid. Many of the larvæ cease feeding during the day-time, remaining concealed near the plants, and all except very young larvæ drop to the ground when disturbed, so that one cannot readily observe them upon the plants. When ready to pupate, the larva spins a loose cocoon just below the surface of the ground, or in rubbish upon the ground. The duration of the pupal state apparently varies from ten to thirty days, according to climate.

Lepyrus is similar in form to *Phytonomus*. *L. colon*, an ashy-gray European species, about 0.45 of an inch long, is found in Hudson's Bay Territory, and is very common on the stunted willows near the summits of the White Mountains in New Hampshire.

Ithycerus noreboracensis is a gray weevil, dotted with black, and has a yellow scutellum; its antennae are straight, not geniculate; its length is about 0.5 of an inch.



FIG. 385. — *Ithycerus noreboracensis*.

Although the larvæ breed in the tender twigs of bur-oak (*Quercus macrocarpa*), the adult beetles eat the tender shoots and bark of the apple. It is found from Canada to Texas.

In the United States *Bruchus pisi*, of the Bruchidæ, is generally termed the pea-weevil, but in England *Sitones lineatus*, the mystery of whose life history has been lately solved by Mr. T. H. Hart, is the pea-weevil. It is a brownish-gray beetle, rather slender, and only about 0.15 of an inch long. As imago it has been long known to eat the leaves and stems of beans, peas, and other leguminous plants, often totally ruining fields of young peas; lately the larvæ have been discovered to attack the roots of the same plants.

The weevils of the sub-family Otioryhynchinae differ from those of the Curculioninae in having mandibles that are provided in the pupal state with a piece which is regularly deciduous in the early part of the imago state, and which, consequently, leaves a scar upon the mandibles.

Many species of Otioryhynchinae are beautifully ornamented with scales. The most brilliant species belong to the South American genera *Lordops* and *Entimus*. *E. imperialis*, the diamond-beetle, is from 1 to 1.25 inches long, really of a black ground color, but its surface is deeply punctate, and the punctures are lined with brilliant scales, the predominant color of which, as seen against the black background, is bright green. These scales are so numerous that the beetle appears green instead of black. If some of these scales be scraped off with a fine-pointed knife and examined under the microscope, most of them will be found to be oval, about 0.006 of an inch long; by transmitted light the scales are red, blue, and yellow,—chiefly red; by reflected light they have colors complimentary to those seen by transmitted light, consequently mostly green, thus explaining why the scales on the black background furnished by the beetle appear green. The peculiar, changeable nature of the colors indicates that the coloration of these scales may be only optical, not produced by pigment within them. That the color is produced by interference of luminous waves is easily shown by putting a drop of chloroform on the scales upon a microscope-slide, when the colors will vanish only to reappear when the chloroform has evaporated, an experiment that may be repeated an indefinite number of times with the same scales.



FIG. 386. — *Entimus imperialis*.

Aranigus fulleri, an oval black weevil, lightly covered with dark brown scales, and about 0.25 of an inch long, does much damage, both as larva and imago, to roses in greenhouses. The larvæ devour the roots; the imagos disfigure the leaves and flowers, and even eat into the unopened buds. This species is distributed from New England to California, and in the latter locality attacks several kinds of out-door shrubs.

The sub-family Attelabinae includes weevils which have the abdomen alike in the male and female, the elytra without lateral fold on their inner surface, the labium wanting, and the mandibles stout and pincer-shaped.

Attelabus rhois, a reddish pubescent weevil, quite robust, and about 0.2 of an inch long, with short proboscis, is quite common on the hazel (*Corylus*) in the northeastern United States. The species of *Attelabus* roll up the edges of the leaves of their food plant to form a protecting cell for their eggs and larvæ.

The weevils belonging to the sub-family Rhynchitinae differ from the Attelabinae in having flat mandibles, which are toothed on both outer and inner edges.

Rhynchites bicolor is about 0.2 of an inch long, and is shining black and red. In New England specimens the elytra, prothorax above, and head as far as the eyes, are red. Specimens from other localities vary in the distribution of the red, but the prothorax above and the elytra are always red. This species is abundant throughout the United States, on wild roses.



FIG. 284. *Rhynchites longicollis*.

SUB-ORDER III.—HETEROMERA.

The Heteromera have the anterior and middle tarsi five-jointed, while the posterior tarsi have only four joints. Besides some anomalous families containing but few species, this group of beetles includes the Meloideæ, Stylopideæ, Mordellidæ, Anthicidæ, and Tenebrionidæ.

The MELOIDÆ, oil-beetles or blister-beetles, have been used in oriental medicine as early as history gives any account of the mode of treating diseases, but, however curious medical properties they have, they are, to the naturalist, still more curious on account of their remarkable life history, and the strange modifications which parasitism has produced in the larval stages of many of them. The beetles themselves are generally of medium or large size; the vertical head is abruptly narrowed behind into a neck, and is not set into the prothorax; the antennæ are generally eleven-jointed, and not long; the thorax has no lateral suture, and is narrower than the elytra; the hind coxæ are large and prominent; the coxal cavities are open behind; the claws are cleft or toothed; the elytra are sometimes small, and overlap each other at the suture, although they often fail to cover the abdomen.

Species of *Meloe* exude a yellow fluid from the knee-joints when disturbed. This fluid is of a disagreeable odor, and contains, according to P. Magretti, uric acid. Leydig states that, as in the similar fluid from Coccinellidæ, this is only the blood of the insect. Among the curiosities of the anatomy of Meloideæ, may be mentioned the eyeless genus *Melotryphus*, from Peru, and the proboscis which is present in some species of *Nemognatha*. Dr. Hermann Müller has described the proboscis of one South American *Nemognatha* which is as long as the insect itself, and is made up of the two maxillæ hollowed out on their insides and pressed together laterally, forming a tube for sucking honey, exactly as is the case with the proboscis of the Lepidoptera.

The blistering properties of cantharides, which gives them their value as a medicine, is due to the presence in all parts of the insect of a substance called cantharidin. Ordinarily, cantharides are used for making blister-plasters in the form of a powder, made by simply grinding the dried beetles, but as the cantharides, both before and after grinding, gradually lose their strength, on account of the action of other substances in them upon their cantharidin, and as they are likewise subject to destruction by museum-pests (*Anthrenus*) and by other insects, it is better to extract the

pure cantharidin for use in preparing medicines. Pure cantharidin ($C^5H^6O^2$) is insoluble in water, sparingly soluble in alcohol, and readily soluble in ether; with the latter fluid it can be extracted from cantharides, and then purified by separation from the accompanying oils and by crystallization. Cantharidin crystallizes in colorless, four-sided prisms or laminae. Although *Lytta vesicatoria* (the so-called Spanish fly) is the species generally used in medicine, other Meloidae—among which may be mentioned species of *Mylabris*, *Epicauta*, and *Macrobasis*—have been used, and give a larger percentage of cantharidin than is obtained from *Lytta vesicatoria*. Probably all species of Meloidae are vesicant to a greater or less degree. In preparing Spanish flies for the market, they are killed by heat, and then rapidly dried. The extent to which these insects were used in early times is indicated by the eighty-five citations, given by Jördens in 1801, of works in which considerable mention of cantharides is made.



FIG. 388. — *Epicauta vittata*.

Species of Meloidae are injurious as well as useful: a number of species devour potato-leaves, both in this and in other countries. In Italy *Lytta erythrocephala* sometimes devastates potato-fields; in this country *Epicauta cinerea*, *E. pensylvanica*, *E. vittata*, and *Macrobasis unicolor* attack potatoes in addition to other plants. *E. vittata* and *M. unicolor* are, however, known to prey at times upon the larvæ of the Colorado potato-beetle.

The mode by which the Meloidae develop from the egg to the imago has been termed hypermetamorphosis. In brief, it is as follows: The egg, which is laid in the ground, hatches into an active larva, called the triungulin, from the name *triungulinus* given to it by Dufour in 1828. These triungulins, or first larvæ, run actively about; some of them ascend plants, others live in sand, their mode of life varying according to what their subsequent history will be. The triungulins which climb plants, as do those of *Meloe*, remain about the flowers, attaching themselves to flies, bees, and wasps that visit the flowers for honey, and were described by several early naturalists as bee-lice. The triungulins of *Meloe* are sometimes so abundant, according to Dr. C. V. Riley, on hive-bees, as to worry them to death, although he believes these triungulins "cannot well, in the nature of the case, breed in the cells of any social bee whose young are fed by nurses in open cells." Those triungulins that attach themselves to such wild bees and wasps as are fitted to further their development are carried by these Hymenoptera to their nests, wherein they go from the bee to its egg in a cell, and devour the egg, after which a moult takes place, and the triungulin, formerly so active, is converted into a clumsy second larva, which feeds upon the honey provided for the young hymenopteron. The second larva then partially moults, remaining, however, within its skin, and becomes a pseudo-pupa. A third larva follows by similar partial moulting of the pseudo-pupal skin, and finally a true pupa and imago. Certain triungulins, or first larvæ, which wander about the ground, as do those of *Epicauta* and *Macrobasis*, have been found by Dr. C. V. Riley to feed upon the eggs of the Rocky Mountain locusts (*Caloptenus spretus*) and upon eggs of *C. differentialis*. The triungulin which devours locust eggs moults to enter what Dr. Riley has called, on account of its resemblance to larvæ of Carabidae, the "carabidoid stage of the second larvæ;" another moult transforms it to what the before-mentioned author has termed, because of resemblance to larvæ of Scarabæidae, the "scarabæidoid stage of the second larvæ;" still another moult produces what, following Dr. Riley's nomenclature, is the "ultimate stage of the second larvæ." Leaving now, for the first time, the

egg-mass of the locust, this larva forms a cavity in the ground, partially moults, and enters the pseudo-pupal (sometimes termed coarctate larval) stage. Usually hibernation takes place in this stage. The third larva is revealed in the spring by a shedding of the pseudo-pupal skin. The third larva burrows about the ground, without feeding, soon pupates, and the imago emerges shortly after. The stages of the Meloidæ parasitic upon bees, and of those which are devourers of locust eggs, can be more easily understood and compared with the ordinary metamorphoses of Coleoptera by a glance at the following tabular arrangement:—

BEET-PARASITES.

Egg.

Triangulin (1st larva): Active, often a plant-climber; bee-parasite, and egg-eater.

Second larva: Sluggish, and a honey-eater; usually with two moults.

Pseudo-pupa: Coarctate larva, is a resting stage.

Third larva: Again active, but does not feed.

Pupa.

Imago.

DEVOURING EGGS OF ORTHOPTERA.

Egg.

Triangulin (1st larva): Active, running about the ground; an egg-eater.

Second larva: An { carabidoid stage,
egg-eater. { scarabæidoid stage,
ultimate stage.

Pseudo-pupa: Coarctate larva, is a resting stage.

Third larva: Again active, but does not feed.

Pupa.

Imago.

Lytta vesicatoria, the Spanish fly, is a bronze green species, about 0.75 of an inch long, and is found in middle and southern Europe and in southwestern Asia, where it feeds upon ash (*Fraxinus excelsior*), lilac, and other trees. Curiously enough, the



FIG. 389.—*Lytta vesicatoria*, Spanish fly.

life history of this insect, which was so long used for medicinal purposes, remained almost unknown until 1879, when J. Lichtenstein published an account of rearing the imago from the triangulin, which latter fed upon eggs of *Ceratostyle chalcites*, a hymenopterous. The triangulin, which is, of course, very small, has strongly protuberant eyes, and two long caudal appendages. In five or six days the triangulin changes to the second larva, a little white grub, with six feet. The mandibles, sharp in the triangulin, are short and blunt in the second larva, which feeds on honey. After five days the second larva moults, the mandibles are still more blunt, and the eyes less prominent. At the end of a second five days' period another moulting takes place, the eyes entirely disappear, and the larva becomes scarabæidoid. The larva now descends into the ground, where, in a small cavity, it pupates in about five days. The pseudo-pupa is similar to the well-known pupæ of Muscids, but has four little protuberances or warts upon the head and three pair of warts in place of feet. The color is yellowish white; and from time to time a clear fluid is exuded from pores of

this pseudo-pupa. In this pseudo-pupal state hibernation takes place, and the next spring the pseudo-pupa bursts open, and the third larva appears. This larva, which otherwise closely resembles the scarabæidoid form before mentioned, has rudimentary mouth-parts and poorly developed, two-jointed feet. After about two weeks, during which time this third larva does not leave the cavity in which it emerged from the pseudo-pupa, it changes into a normally formed beetle-pupa, and in about twenty days more the beetle appears.

Epicauta cinerea, *E. pensylvanica*, and *Microbisus unicolor* eat potato-leaves as imagos, but as larvæ they are useful to man by destroying locusts. The Rocky Mountain locust lays its egg-masses just beneath the surface of the ground, and these species of *Epicauta* oviposit near the locust eggs, in a hole which the female *Epicauta* digs for the purpose, afterwards covering her eggs by scratching dirt over them with her feet. The



FIG. 300. — *Epicauta cinerea*.

eggs hatch in about ten days, and the light brown triangulins, if the weather is warm, soon begin searching out locust eggs for food; if it is cold weather they remain closely huddled together until warmth induces activity. Dr. C. V. Riley observes: "Should two or more triangulins enter the same egg-pod, a deadly conflict sooner or later ensues until one alone remains the victorious possessor." After devouring about two eggs, that is, at the end of about eight days after beginning to feed, a moult takes place, and the second larval form appears, the form designated as carabidoid. The carabidoid form lasts about a week, the succeeding scarabæidoid form about a week; after reaching the ultimate stage of the second larva, it feeds about a week, then leaves the remnants of the locust's egg-mass, and rounds out for itself a smooth cavity in the ground. After being in this cavity about four days, a moult takes place, but the skin is not entirely shed. The soft skin quickly hardens, and the insect is now a pseudo-pupa. After hibernating as pseudo-pupa, the skin again bursts, and the third larva appears. This third larva burrows about in the ground, and in a few days the true pupa is formed, from which, in five or six days, the imago appears. The functional significance of the third larva, which, in these insects as in *Lytta vesicatoria*, eats nothing, is not yet understood.

The genus *Mylabris* includes over two hundred and fifty beetles in which the elytra cover the entire abdomen, the mandibles are short, the antennæ are gradually enlarged toward the apex. The species are often black or blue-black, banded with yellow, and of considerable size. No true *Mylabris* is found in the United States. *Cordylos-pasta falleri* from Nevada, with eight-jointed antennæ, is an allied form to *Mylabris*.

Sitaris differs from *Mylabris* in having wings partly exposed, and the rudimentary elytra narrowed rapidly behind, and not reaching the tip of the abdomen. The first to describe all the different stages of any species of Meloidæ was J. H. Fabre, who, in 1857, published his account of the metamorphoses of *Sitaris homeralis*, a French species, which is parasitic on bees of the genera *Anthophora* and *Bombus*. Fabre's account of the life history of *S. homeralis* is briefly given as follows: The males and females, as soon as they have emerged from the pupæ, pair in the subterranean nests of the bees upon which they are parasitic, and the female lays soon after about two thousand eggs, near the entrance of the nest. The triangulins, which hatch in about a month, hibernate, without feeding, among their egg-shells, and the next spring attach themselves to the hairs upon the thorax of the male bees, from which they probably pass over to the females during the pairing of the bees. Thus

far the history of their life is sufficiently strange, but the next change of habitat is still more curious. At the moment when the female bee deposits her egg upon the surface of the honey in her cell, the active young triungulin passes from the bee to the egg, upon which the larva rides, as upon a boat, thus avoiding drowning in the honey about it. The bee's cell is sealed, and then the triungulin begins eating into the egg of the bee; the contents of this egg just suffices as food for the larva about eight days, when it moults and appears as the second larva. This second larva, unlike the triungulin, is not in danger of drowning in the honey about it, and feeds upon it. In the latter part of summer the second larva attains full growth, and enters the pseudo-pupal state. Most of these insects hibernate as pseudo-pupæ, although a few appear as imago about the beginning of September. The pseudo-pupæ which hibernate go through the third larval and the pupal stages from June to August of the next year, appearing as beetles about the middle of August.

Hornia minutipennis, an American species allied to *Sitaris*, was found by Dr. C. V. Riley to be parasitic upon *Anthophora spousa*, but its life history is still incomplete. The imago is about 0.5 of an inch long, with no wings, and the elytra are so extremely rudimentary as to be scarcely noticeable.

Among other genera of Meloidæ of which more or less is known concerning their life history is *Zonitis mutica*, a French species, whose hypermetamorphosis takes place in cells of *Osmia tridentata*.

Meloe includes wingless beetles, which have very short, imbricated elytra that do not nearly cover the abdomen. *M. angusticollis* is a steel-blue species common in the eastern United States. Its length is from 0.40 to 0.75 of an inch.

The females of *Meloe* are very prolific, and sometimes lay as many as from three to four thousand eggs. The life history of *Meloe* has not been as well studied as has that of *Sitaris*, but there is no doubt that its earlier stages are passed, in analogous mode to those of *Sitaris*, in the nests of bees.

The STYLOPIDE are insects of very abnormal structure and habits, and are regarded by some naturalists to be a separate order, Strepsiptera, and by others are assigned to this position next the Meloidæ. The males have rather peculiar form, small, partially rolled up elytra, and very large wings which fold like a fan. Their eyes are large,



FIG. 331. — *Meloe angusticollis*.



FIG. 332. — *Xenos pecki*: a, Elytra.

coarsely faceted, and, in *Stylops* and *Xenos*, are mounted upon pedicels. In the adults of both sexes the mouth-parts are rudimentary. Prothorax and mesothorax are short; the metathorax is, on the contrary, greatly developed. Sexual dimorphism is carried to its extreme degree among the Stylopidae, and although the males are capable of locomotion and possess good eyes, the adult females are wingless, eyeless, and legless parasites, remaining buried between the abdominal segments of wasps, bees, and ants, there enclosed in their pupal-skin which they

never shed, and pushing out into open air only their anterior end between the segments of their host. Their eggs, which drop directly from the ovaries into the body-cavity, develop in the latter place, possibly parthenogenetically at times, although

pairing has been often observed. The larvæ are hatched in the body-cavity; the Stylopidae are consequently viviparous. These hexapodous larvæ, which are very active and have eyes, escape by a dorsal opening from their mother, and, running about on the female bees, are transported to the nest, where they quickly bore into and bury themselves in bee-larvæ. Once inside a bee-larva, the larva of the *Stylops* moults in about a week, and appears as a footless grub which feeds upon the fatty portions of the bee-larva. When the bee-larva pupates, its parasite pupates within it. In becoming an imago, the female *Stylops* only bores out through the end of her own pupal skin, and through one of the soft folds of the abdomen of the bee, protruding her head and thorax between two segments of her host, but never leaving her pupal skin. The males leave the pupal skins, search out females, pair, and die, usually in a few hours. Each female is supposed to bear about two thousand young larvæ, many of which, on account of their strange mode of life, die without finding a suitable place for further development.



FIG. 283. — *Xenus rossii* female.

There are but few genera and species of Stylopidae, among which the following genera are perhaps best known, — *Xenus*, with four-jointed antennæ and four-jointed tarsi; *Stylops*, with six-jointed antennæ and four-jointed tarsi; and *Haliotophagus*, with seven-jointed antennæ and three-jointed tarsi.

Westwood has described a pupa, which he regards as belonging to the Stylopidae and which was found in the abdomen of a hemipteron, under the name of *Colacina insidiator*; and the same author has also described a species, under the generic name *Myrmecolax*, which is parasitic on ants in Ceylon.

The Rhipiphoridae, a family containing only about a hundred described species, includes insects, like so many other heteromerous Coleoptera, remarkable both for abnormal adult structure and for parasitical earlier stages. The larvæ of some are parasitic on Hymenoptera, of others on Orthoptera. The beetles are all comparatively small and generally wedge-shaped, the anterior portion of the prothorax and the posterior portion of the abdomen usually diminishing gradually in size. The head is vertical, and has large eyes; the mouth-parts are well-developed, and the antennæ have usually ten, in some females eleven joints, and are pectinate or flabellate in the males, and often serrate in the females. The elytra are usually shorter than the abdomen, often acutely pointed behind and dehiscient, sometimes very minute; a few females resemble larvæ, and want both wings and elytra. The beetles inhabit flowers.

Some discussion has arisen as to the actual food and mode of life of the larvæ of Rhipiphoridae in wasps' nests, but the following brief abstract of statements made by Mr. A. Chapman in an account of the life history of *Rhipiphorus (Metecus) paradoxus*, a common European species which develops in the nests of *Vespa germanica* and *V. vulgaris*, are probably the facts of its mode of life. The female beetle probably lays its eggs outside the wasps' nests; the young larva, which has ocelli and is not unlike the triungulin of the Meloide, comes into the nest, possibly without help, and enters the cell of a wasp-larva. Before the cell of the wasp-larva is closed up the *Rhipiphorus*-larva bores in between the second and third dorsal rings of the wasp-larva. Later the *Rhipiphorus*-larva, after feeding a while in the wasp-larva, breaks out through the fourth ring of its host, moults immediately, and becomes a grub with poorly developed legs. The parasitic larva now fastens itself firmly upon the fourth ring of the wasp-larva, where it later moults again; soon after this moult the parasite has

sucked the juices entirely out of the wasp-larva, and pupates in its cell. The whole process requires from twelve to fourteen days, and the beetle emerges two days later than the wasps in the same row of cells. *Myodites subdilectus*, another European species, has been reared from nests of *Holictus saccinctus*. *Rhiphidius*, a European genus, has larviform females without wings or elytra; its larvæ are parasitic in the abdomen of cockroaches.

The MORDELLIDÆ are beetles similar in general appearance to those of the last-described family, but they differ from those of that family in having a distinct lateral suture of the thorax, and in having filiform antennæ. The larvæ of the Mordellidæ are not parasitic as are those of the three preceding families, but live in fungi or twigs; the larvæ have short legs, on which the joints are not distinctly indicated. The beetles themselves are of small size, and, like the Rhipiphoridæ, are found on flowers.



FIG. 391. — *Mordella ornata*.



FIG. 395. — *Mordella octopunctata*.

Very few of the American species of this family have been reared. Mr. V. T. Chambers has reared a species of *Mordella* from a larva feeding in pith of *Vernonia*, and mentions the occurrence of similar larvæ in the galls of *Gelechia gallsolidaginis* on *Solidago*.

The ANTHICIDÆ, a family of beetles mostly of small size, are generally found on flowers, although some species are inhabitants of sandy places near the water. These beetles have the head constricted behind the eyes, the lateral suture of the narrow prothorax is wanting, the rounded elytra cover the entire abdomen. In *Notoxus* and *Anthicus*, two genera with numerous species, the head is deflexed and narrowed behind the oval, coarsely-granulated eyes. In *Notoxus* the prothorax extends out over the head in a sort of horn; in *Anthicus* there is no prothoracic horn; and in the ant-like genus *Formicomus*, which is closely related to *Anthicus*, wings are absent. But little is known of the life history of the Anthicidæ. *Tanarthrus salinus*, from the Colorado desert-lands, and from Utah, runs and flies along the salt mud much in the same way as do species of *Cicindela*.

The family of the TENEBRIONIDÆ, as usually limited, includes between four and five thousand kinds of beetles, mostly of rather sombre coloration, although a few species are marked with red or are bronzed. Le Conte and Horn say that, "This family contains a large number of genera, possessing in common very few characters, yet linked together by such gradual changes in structure that their classification presents almost insuperable difficulties." The beetles of this family have, according to the above-named authors, simple claws, anterior coxal cavities closed behind, five ventral segments which are in part connate, and the penultimate joint of the tarsi not spongy beneath. They may be divided into three sub-families. These are the Tenebrioninae, having the third and fourth ventral segments with a coriaceous posterior margin; the Asidinae, having the ventral segments entirely coriaceous and the middle coxæ with a distinct trochantin; and the Tentyriinae, having the ventral segments entirely coriaceous, as in the Asidinae, but the middle coxæ without trochantin.

The larvæ of Tenebrionidæ are elongated, often resembling, in a general way, the so-called 'wire-worms,' the larvæ of Elateridæ. The larvæ have four-jointed antennæ, five-jointed legs, are provided with from two to five ocelli on each side of the head, and often have a pair of anal appendages to aid in locomotion. The larvæ feed upon

fungi, upon dead animal and vegetable matter, upon dung, and upon plant-galls; the larvæ of *Hyppophæus ferrugineus* devour the larvæ of *Tomicus stenographus*, and the larvæ of *Tribolium ferrugineum* and of *T. castaneum* are museum pests. The larvæ as well as the imago of the Tenebrionide are usually abundantly parasited by intestinal Gregarina; of some species of Tenebrionide one cannot find an individual, upon dissection of large numbers, that does not harbor one or more species of these parasites.

The geographical distribution of the Tenebrionide is somewhat remarkable. On the eastern coast of North America the family is poorly represented, but the number of genera and species in the fauna increases toward the west, until, upon reaching California, they are among the most abundant Coleoptera. They are especially abundant also along the western coast of South America, and in Europe.

The uses to which Tenebrionide have been put are comparatively few. The larvæ of *Blaps mortisaga* are said to be roasted and eaten by Egyptian women, and the larvæ of *Tenebrio* and *Alphitobius* have been reared in zoological gardens as food for amphibians and insectivorous birds.

Among the beetles belonging to the sub-family Tenebrioninae are those of the genus *Illops*. In *Illops* the tarsi are slender, the abdomen not pedunculate, and there is a coriaceous band above the labrum; some of the species are wingless, and their form varies from oblong to oval. Some of the species of *Illops* are beautifully striped longitudinally with changeable bronze lines. This is especially the case with *Il. micans*, found in the northeastern United States. The larvæ of *Il. striatus*, a European species, has been found living in decayed coniferous wood, feeding not only upon the wood but upon the excrement of wood-boring longicorn larvæ. *Il. pallus* has been found in Illinois about apple and peach trees that had been attacked by borers.

Bolitotherus bifurcus is a curious rough beetle not uncommon in the northeastern part of the United States and in Canada about species of *Polyporus* and other fungi upon trunks of trees. It is from 0.4 to 0.5 of an inch long, and dull brown, the lateral margins of the prothorax are flattened and extend forward each side of the head; two protuberances upon the dorsum of the prothorax are short in females, but in males extend upward and forward to form veritable horns, which are of variable length, are flattened out from above and below, and are fringed with light brown hairs around their margins. The antennæ are short and ten-jointed. The larvæ feed in holes which they burrow in fungi. They are about 0.75 of an inch long when full grown, long and narrow, with the abdomen ending in two spines. Pupation takes place within the fungus. *Eledona agaricola*, a European species closely related to *Bolitotherus*, has similar habits.



FIG. 386. — *Bolitotherus bifurcus*.

Diaperis has a short, oval form, smooth surface, and the first joint of the hind tarsi not exceeding the second in length. *D. hydni* is about 0.25 of an inch long, the elytra are red spotted with black, the rest of the insect is black; it is very common upon *Polyporus betulinus*, a large fungus that attacks dead white-birch trees, and in which the larvæ of the beetle feeds. *D. boleti*, from Europe, is a trifle larger than *D. hydni*, and has a broad, irregular black band across the middle, and a similar band near the apex of the elytra; its habits are like those of *D. hydni*. *Hoplocephala* differs generically from *Diaperis* in having the first joint of the posterior tarsi as long as the second and third joints. *H. bicornis*, a smooth beetle, only about 0.15 of an inch long, and of a

metallic-green color with brownish legs, is very common on various kinds of small fungi growing on bark of dead trees and stumps. The male is distinguished from the female by two slender horns that surmount the head; the female has the general aspect of a small species of Chrysomelidae. The species of *Platypont* are oval, somewhat flattened beetles, and have the first joint of the posterior tarsi longer than the second and third joints. Their larvae feed upon fungi under bark.

In the genus *Tenebrio* are included black, elongated, winged beetles, in which the antennae are gradually thickened toward the tip, the epipleurae entire, the legs slender, and the entire insect of a dull-black color. The larva of *T. molitor* is the well-known meal-worm, and all stages of the insect are found about granaries and bake-houses, where they are very destructive to stored grain and all farinaceous matter. Some of the species of *Tenebrio* are found about decaying wood, and Chapuis and Camfôze write that these, as well as other larvae of Tenebrionidae, may be distinguished from the larvae of Elateridae — the wire-worms — which they so closely resemble, "by the structure of their mouth-parts, that is by the attachment of the lobe to the basal piece of the maxillae, and by their visible clypeus and labrum."



FIG. 337. — *Tenebrio obscurus*.

Upis ceramboides, a black beetle with slender legs, common in the eastern United States, is about 0.75 of an inch long. Its thorax is finely punctate when examined with a lens, although it appears smooth to the naked eye; its elytra are deeply and irregularly indented. It is found under bark, as is also *Iphthinius opacus*, a beetle of about the same size, which has both thorax and elytra coarsely punctured. *Nygrobates pennsylvanicus*, found in the same regions as *Upis ceramboides*, resembles the latter in form and size, but has elytra upon which fine punctures are arranged in very regular striae.

In California and Arizona are three genera — *Stenotrichus*, *Cratidus*, and *Amphidora* — which, contrary to the general rule in Tenebrionidae, are densely pubescent with long, erect hair; the species are all wingless. One of the largest of these pubescent species is *Cratidus osculans*, which is about 0.6 of an inch long, black, densely punctate, and out of each minute depression arises an erect brown hair.

Blaps and *Elaeodes*, two well-known genera of the Tenebrionidae, belong to a group in which the connate elytra partly embrace the body, and in which the tarsi are spinose or setose beneath. *Blaps* is a genus containing numerous species distributed over Europe, northern Africa, and western Asia. *B. mortisaga*, a common European species, has been introduced into America, and is abundant at Alexandria, Va. It is about an inch long, entirely black, and is found in cellars, caverns, and other obscure places, where it feeds upon animal refuse. The larva of *Blaps* is similar to that of *Tenebrio*, but larger, and lives in obscure nooks. *Elaeodes* contains about fifty species, which are all found in the western United States, where they devour excrement and dead matter, and seem to fill the place occupied in the eastern hemisphere by *Blaps*. Some of the species of *Elaeodes* are quite large, *E. obscura*, a robust species, and *E. gigantea*, a slenderer species with long legs, being about 1.25 inches long.

Dr. G. H. Horn stated in 1867 that certain Californian species of *Elaeodes*, when disturbed, elevate the abdomen nearly vertically, and if seized discharge an oily fluid from the abdomen. An analogous disagreeably odorous secretion is used as a defence



FIG. 338. — *Blaps mortisaga*.

by *Blaps mortisaga*, *B. obtusa*, and others of the same genus. The odorous fluid, both of *Blaps* and of *Eleodes*, is secreted by two glands, one on each side, near the anus, from which it is ejected, sometimes in the case of *Eleodes longicollis* to a distance of three or four inches. Mr. C. F. Gissler, who has examined the secretion of *Eleodes*, states that it has an acid reaction, stains the skin brown and causes lachrymation; has a very penetrating, indescribable odor; is soluble in water, alcohol, and ether; and sometimes crystallizes on a glass, forming an orange-colored magma of minute crystals. *Blaps obtusa*, according to Hornung and Bley, contains a red pigment, volatile and fatty oil, resin, formic and uric acids, and wax, besides chitin and other substances. Kirby and Spence write that, "Pliny tells us of a *Blatta*, which, from his description, is evidently the darkling-beetle (*Blaps mortisaga*), and which he recommends as an infallible nostrum, when applied with oil extracted from the cedar, in otherwise incurable ulcers, that was an object of general disgust on account of its ill scent, a character which it still maintains."

The sub-family Asidine contains numerous genera, among which *Asida* is well known since it is represented by numerous species in the European fauna and by over thirty species, all from west of the Mississippi River, in the United States. The species of *Asida* inhabit desert regions. They are apterous and have an ovate body.

The sub-family Tentyriine contains, with few exceptions, apterous species. The only species of the Tentyriine found in the northeastern United States is *Phellopsis obcordata*, which is found from Maryland to Canada. It is about 0.55 of an inch long and one-third as wide, is dark brown, is roughened by deep punctures and prominent elevations, and has the anterior portion of the prothorax winged laterally. It is found upon fungi in localities similar to those frequented by *Bolitotherus bifurcus*, which its color and rugosity recall.

SUB-ORDER IV. — PENTAMERA.

The Pentamera, the group of beetles normally having tarsi with five joints, includes all the Coleoptera to be described hereafter in this work, and probably contains about one half the known species of Coleoptera. Omission is made of some of the smaller and less interesting families in order to allow more space for those families which are of most importance.

The family LYMEXYLONIDÆ contains but four genera and a limited number of species, but the destruction of ship-timber in western Europe by *Lymexylon navale*, and Linnaeus' application of a remedy by immersing the timber during the time of oviposition of the beetle, early called the attention of naturalists to this species. The species of this family have a deflexed head, which is narrowed behind; the eleven-jointed serrate antennæ are inserted on the sides of the head; the coxæ are all contiguous in the three American genera, but in *Atractocerus* the anterior coxæ are separate; the legs are slender. *Lymexylon* has entire elytra and the abdomen with five ventral segments. The species generally resemble those of certain Elateridæ, or spring-beetles, later to be described. The larvæ of *L. navale* are slender, six-legged grubs; the head is small, the first segment enlarged, and the last segment bears a leaf-like appendage above. These larvæ make long cylindrical burrows in oak wood. None of the *Lymexylonidæ* are sufficiently abundant in America to cause damage. *Micromalthus debilis*, a minute but interesting species, has been reared by Mr. H. G. Hubbard, from decayed wood found in Detroit, Mich.

The species of PRINIDÆ are generally small; their antennæ are variable in form and place of insertion, and have from nine to eleven joints; the head is quite retractile, so much so as to be often protected by the prothorax; the elytra are entire. The food-habits of this family are very diversified; both larvæ and imagos show a preference for dead animal or vegetable matter, although living plants do not escape their attacks. The larvæ eat drugs, even devouring capsicum, tobacco, allspice, and other material not generally acceptable to insects; they also bore in both living and dead fungi, bark, twigs, roots, and wood of many kinds; and one species, *Catorama zea* from the Barbadoes, lives somewhat after the manner of *Bruchide*, in maize.

A common beetle belonging to this family, that attacks apple trees in the middle United States, is *Amphicerus bicaudatus*, which is about 0.3 of an inch long, of a cylindrical, slender form, and of a dark-brown color. Its specific name is derived from the fact that the males have two small thorns projecting from the posterior end of the body. This species does not, in all probability, breed in young twigs of apple, although it may often be found in them, head downward, in burrows which occupy one or two inches of the pith of the twigs, and extend downward from an opening by which the beetle has entered the twig. These burrows are used only for hibernation, and the larval history of this beetle is not yet known. Similar injuries to those which *A. bicaudatus* cause in apple twigs are also produced by the same species of beetle in pear, peach, and grape twigs. In Europe beetles of the genera *Apate* and *Lineogylon*, closely related forms to *Amphicerus*, attack grape twigs, as well as the bark and wood of numerous trees.

Lasioderma serricornis, a small species of this family, eats, as larva, capsicum and dried tobacco. *L. lutea* attacks stems and leaves of dried tobacco, often doing much damage to them. The former is found in both Europe and America; the latter is European. *Catorama*, of which one species has been mentioned as eating maize, differs from *Lasioderma* in not having serrate antennæ. *C. tabaci* attacks cigars in Cuba, and *C. sallei*, from the West Indies, undergoes its metamorphoses in the pods of a plant closely like Saint-John's-bread.

In *Anobium* the form is elongated, somewhat cylindrical; the eleven-jointed antennæ are inserted just in front of the eyes, and the metasternum is deeply excavated in front. These little beetles, which are generally black or brown in coloration, and about 0.25 of an inch long, have received the name of death-watch on account of a peculiar ticking sound which they produce in the wood of houses, a sound which was supposed, by superstitious people, to presage death to some member of the household where it was heard. The sound itself consists of from six to twelve sharp, distinct ticks, at nearly as regular intervals as the ticks of a clock; then a pause of a minute or more occurs, and the sound is repeated, often in another locality from that where it was first heard. As this ticking is generally emitted when there is no other disturbing noise, often in the stillest part of the night, one can scarcely wonder that people who do not know its cause should listen to it, perhaps while watching at the sick-bed of a friend, with hushed breath, and should associate its sounds with death. The sounds are really, however, only signals by one beetle to discover another of its species; probably, as in many other insect-noises, they have a sexual significance, and serve to guide one sex to the other. At any rate, by deftly imitating their call by snapping with the finger-nail upon a piece of hard wood, the beetles can be deceived into repeatedly answering your telegraphic message. The mode by which the beetle produces its sound was first observed by Swammerdam, the distinguished Dutch

anatomist, over two hundred years ago, and has since been described by several naturalists. The rapping is caused by a forcible hammering of the hard wood with the head of the beetle, and it is noticeable that the beetle selects places where the wood will act as a sounding-board for its curious sonification.

The larva of *Anobium* is cylindrical, short, often slightly dilated toward the posterior extremity, and has six legs; it has no ocelli, short antennae, a labrum which reaches nearly to the extremity of the short, stout mandibles; its anal opening is longitudinal. The larvæ sometimes develop in one year, and sometimes require longer. Both beetles and larvæ often do much damage to furniture, books, drugs, and provisions. Linnaeus found that *A. pertinax* destroyed his chairs; Kirby and Spence complain that *A. striatum* has the same habit, and also injures picture-frames and the boards of floors. Both of these species of *Anobium* attack books, not only for the leather with which they are bound, but also for the paste used in their binding. Spence mentions wholesale destruction of oaken beams used to support floors in the old mode of building houses in Belgium, necessitating renewal of these beams at great expense.

Sitodrepa panicea, a cosmopolitan species often mentioned under the name of *Anobium paniceum*, differs from *Anobium* by not having the metasternum excavated in front. It is a brown beetle densely covered with light brown pubescence, and about 0.12 of an inch long. The earlier stages of this beetle were described in 1721 by Frisch, who found the larvæ devouring the inside of a piece of rye-bread. Later the same author writes that this insect injures books, and attacks many kinds of dead animal matter. Prof. A. S. Packard mentions finding this species in wasps' nests preserved in museums, where it probably ate the dried wasps left in the nests. Dr. H. Shimer has raised this species from larvæ feeding in red beads "made of some kind of colored paste."

The genus *Ptinus*, of which *P. fur* is a widely diffused representative, differs from *Anobium* both in form and in having the long filiform antennæ inserted closely together upon the front. *Ptinus fur* is of an uniform brown color, and is pubescent; it is only about 0.1 of an inch long. De Geer described and figured the preparatory stages of this species in 1774. This species is known as a museum pest, attacking insects and other animals preserved in collections. I have found it swarming in barrels of wool which had been clipped off the fleece and thrown aside because it was full of sheep's dung and other dirt. According to E. Perris the female of *P. dubius*, a French species, oviposits in the male blossoms of *Pinus maritima*. The larva grows rapidly, feeding



FIG. 399. — *Ptinus fur*.

upon the pollen of the pine, and forms its cocoon of pollen-grains cemented together by a mucilaginous secretion. *P. brunneus*, a species found in Europe and in the United States, sometimes attacks the binding of books.

The diversity of habits of the larvæ of Ptinidæ can be easily seen by the above selections from what is known of their life history. They are generally easily destroyed by subjecting the materials in which they feed to heat, or to the action of benzine vapor in a closed tin box. A convenient way of destroying these and other insects in books, in such drugs as are not injured by subjecting them to a dry heat of 100° C, in clothing, and in



FIG. 400. — Larva of *Ptinus fur*.

many other substances, is to put the goods containing insects into a loosely covered tin box or pail and to set this for a time into boiling water, taking care that the water does not boil over into the box containing the goods.

The family of CLERIDÆ includes over seven hundred species of beetles, of which many have beautiful coloration, and a general aspect somewhat ant-like. This ant-like appearance is due to their prominent eyes, their short antennæ, their generally long legs, and their elongated prothorax, which is often much narrower than the elytra and slightly narrower than the head. The antennæ, which are usually eleven-jointed, have the apical joints enlarged, forming a more or less compact serrate club. The posterior coxæ are flat, and the tarsi have membranous lobes. The larvæ of Cleridæ are mostly predaceous, inhabiting the burrows of xylophagous coleoptera, or the nests of bees, and feeding upon the living larvæ which they find in these situations; a few (*Corynetes* and *Necrobia*) eat decaying animal matter. Many species of Cleridæ, as imago, frequent flowers, but a large number of them, especially species of *Thamnocerus*, can be found running quickly over dead pine bark, and piles of freshly-cut pine wood furnish the agile insect-collector numerous species.

The species of *Necrobia* which have been introduced into America from Europe, are small pubescent carrion beetles of which the outer three joints of the antennæ form a club. The last joint of the palpi is long and truncate. *N. violacea* is about 0.15 of an inch long and deep steel blue, rarely greenish, in color. *N. ruficollis* is a trifle larger than the last-mentioned species, and its legs, prothorax and the anterior portion of its elytra are dull red. *N. rufipes* differs from *N. violacea* in having brown

legs. The larvæ of *Necrobia* frequents the same places as does the imago; it is of a light brownish-red color, and its abdominal segments increase in size posteriorly, so that the tenth segment is over one-fourth wider than the fourth segment.

Thamnocerus sanguineus is a pretty red species in which the light red elytra are densely punctate, and the brownish-red prothorax is covered with long pubescence. Its life history is unknown. *Clerus ornatus* is a beautiful species from the western coast of North America. Its length is about 0.4 of an inch; its elytra are yellow, marked with very dark shining blue, its prothorax is blue, clothed with long yellow hairs, and its legs are blue.

In *Trichodes* the club of the antennæ is somewhat triangular, the last joint of the labial palpi is dilated, that of the maxillary palpi only slightly larger than the penultimate joint. *T. apivorus*, a well-known European species, is about 0.6 of an inch long. Its ground color is deep blue, but three broad bands of yellow extend from the outer nearly to the inner edge of the elytra; the head, prothorax, and legs are clothed with long pubescence.

The larvæ of this species lives in the nests of wasps and wild bees, and at times in ill-kept hives of honey bees, where it eats not only such half-dead bees as come within its reach, but nests in the honey-comb and



FIG. 401. — *Corynetes ruficollis*.



FIG. 402. — *Thamnocerus sanguineus*.



FIG. 403. — *Clerus ornatus*.



FIG. 404. — *P. rufipes carbonarius*.



FIG. 405. — *Trichodes apivorus*.

devours the larvæ and pupæ of the bees. The imago is found from May to July; the larva remains from July until the next year in the bees' nests. In America *Trichodes nuttalli* is not rare in August upon flowers of *Spiræa alba*, but its larval habits have not been studied. It is about 0.4 of an inch long, and somewhat resembles *T. apiarius* in color and markings. The genus *Aulicus*, which has the apex of both labial and maxillary palpi dilated, is found on the western coast of North America, as is also the very slender *Perilypus carbonarius*, in which the posterior thighs are elongated.



FIG. 406. — *Aulicus nero*.

The larvæ of *Tillus unifasciatus*, a European species, live in dried grape twigs, preying upon larvæ of *Anaspis maculata* and *Apate sexdentata*; and finally pupating in the twigs. It is probable that *T. collaris*, from Georgia, has analogous habits.

The family of MALACHIDÆ is often united with the next succeeding family (Lampyridæ) from the species of which the members of this family differ in having only six free ventral segments, and in the insertion of a separate piece between the front and the labrum.

The genus *Malachius*, and a few of its allies, has excited the attention of many observers on account of its protrusion of two evaginable processes from each side. In *Malachius æneus* each anterior process is trilobed, and is pushed out on each side from beneath the anterior angles of the prothorax; each posterior process is bilobed and originates between the metathorax and first abdominal segment. These processes are of a delicate red or reddish-yellow tissue; they were shown by Dr. H. Liegel to be evaginated by filling with the blood or body-fluid of the insect, and to be retracted by muscles within them. The function of these organs is unknown.

Malachius æneus, the beetle just mentioned, is about 0.2 of an inch long; the anterior angles of its prothorax and the outer portion of its elytra are dull red, the rest of the insect is bronze green. It is found both in Europe and in the United States, having been introduced into the latter country.

The beetle eats the pollen of grass and other plants, and is possibly sometimes carnivorous; the larva lives beneath the bark of trees, where it hunts out and devours the larvæ of other insects.

The LAMPYRIDÆ are beetles of soft texture and medium or small size; the head is sometimes hidden by the front of the prothorax, and sometimes prominent and exposed; the antennæ are generally serrate, and usually eleven-jointed; the elytra, usually quite soft and yielding, may be short or even wanting in the females of certain genera. The larvæ are flattened, often dark-colored and velvety, and have an ocellus on each side the retractile head; they are generally carnivorous, living under stones and bark, or upon the ground, where they devour snails and larvæ of insects. Sometimes the velvety larvæ of certain species of



FIG. 407. — *Malachius marginicollis*.



FIG. 408. — *Malachius affinis*.

Telephorus wander about upon the snow, giving rise to stories of showers of worms.

This family is often divided into three sub-families. The species that have the middle coxæ contiguous, the epipleuræ narrow at the base, and the episterna of the mesothorax not sinuate on the inner side, belong to the sub-family *Telephorinae*; the species of the sub-family *Lampyrinae* differ from those of the *Telephorinae* in having the corresponding episterna sinuate and the epipleuræ usually wide at their bases; while the species of *Lycinae* have no epipleuræ and have the middle coxæ distant.

Of the sub-family *Telephorinae* the genus *Telephorus*, which has an exposed head, is well represented in North America. *T. bilineatus*, a species of which the elytra are blackish brown, finely margined with light brown, and the prothorax brownish red with a longitudinal black spot each side of the median line above, has been reared. The larva is found early in the spring under stones where it pupates in time to disclose the imago in May; the larva is about 0.5 of an inch long, the imago about three-fifths as long. The imago is said to feed on birch leaves.

The genus *Chauliognathus* differs from all other North American *Lampyridæ* in having an extensible fleshy filament attached to each maxillary lobe. The function of these filaments is probably to lap the honey and pollen from the flowers on which the beetles feed. *C. pennsylvanicus* is common in the eastern United States; it is about 0.5 of an inch long, and is yellow and black, as follows: the head, antennæ and legs are black, and there is a black patch upon the yellow prothorax, and an elongated black spot occupies the middle of the apical portion of each yellow elytron. Although these beetles eat pollen and honey, frequenting flowers of thistles and golden-rods (*Solidago*) for the purpose, during late summer, their larvæ are carnivorous and aid the farmers in the suppression of many noxious insects. The larvæ of *C. pennsylvanicus* are known to devour the larvæ of the plum-weevil (*Conotrachelus nenuphar*).



FIG. 409. — *Chauliognathus pennsylvanicus*.

The sub-family of *Lampyrinae* is noted for the luminosity of most of its species. The spectrum of the fire-fly was alluded to in the general remarks concerning the Coleoptera, but the results which numerous experimenters and investigators have obtained in working upon the luminous organs of beetles are worthy of further notice here.

These luminous organs differ in distribution on the abdominal segments of different kinds of *Lampyrinae*, and Motschulsky, in 1853, used the position of the luminous spots, which are yellow on the beetles, in the separation of genera. In finer anatomy the luminous organs, which are homologically parts of the fat-body of the insect, consist of the luminiferous cells wrapped about by capillary anastomoses of the tracheæ. The larvæ, as well as the imagos of *Lampyrinae*, are luminous, and it has been asserted further that the eggs emit light. As Wielowiejsky, who has lately studied the histology of these luminous organs, rightly says, the eggs can be luminous only on account of some external substance which they derived from their mother, or on account of light-giving power of the developing larvæ within them. Matteucci, Jousset de Bellesme, and others have experimented on the conditions which favor or hinder light-production in *Lampyris*. Decapitated specimens retain their power of giving off light, either with or without being subjected to electrical excitement, for four days. High temperature fails to stimulate the action of the luminous organs. In pure oxygen the light is increased in intensity, while no light is emitted in pure

hydrogen, carbonic dioxide, or nitrogen, proving that, whatever is the form of combustion, it is an oxydation. Crushing the luminous organs, as is generally known, temporarily increases the intensity of their light by admitting more oxygen to them; ordinarily their oxygen supply is brought to them by their tracheal capillaries. Entire destruction of the cells of these organs by pulverizing them in a mortar, however, results in producing no light, because the supply of luminiferous matter ordinarily formed by the cells ceases upon their death. In beetles killed by sulphuretted hydrogen the cells are likewise killed, and no further light can be obtained from them.



FIG. 410. — Glow worms. *a*, *Lampyrus splendidula*, male; *b*, female; *c*, larva. *d*, *L. noctiluca*, male; *e*, female; *f*, larva.

Apparently, then, the living cells of the luminous organs secrete, under direct control of the nervous system, a substance, possibly phosphuretted hydrogen, which is luminous when acted upon by the oxygen that reaches these cells through their enveloping tracheal anastomoses. In some species the light is continuous for a considerable time; in other species the light is often interrupted. Mr. A. E. Eaton has observed that, in *Luciola lusitanica*, the flashes are repeated as often as thirty-six times a minute, the duration of each flash being from one-fourth to one-third of a second. When one sex of any species of Lampyridæ emits intenser light than the other sex, the less luminous sex has, as a rule, the best developed eyes; this is especially marked in the case of the large eyes of males of species in which the female is luminous, but apterous.



FIG. 411. — *Photuris pennsylvanicus*.

A common species of fire-fly in the eastern United States is *Photuris pennsylvanicus*. It is about 0.5 of an inch long, and both sexes have wings and long elytra. The color is yellowish, striped with a few ill-defined lines of black or brown. Its luminous larva has a brush-like anal leg. In Europe the common species of fire-flies are *Lampyrus noctiluca* and *L. splendidula*. The females of these species are wingless, each elytron being replaced by a small scale, and these females, as well as the larvæ, are termed glow-worms. The larvæ devour snails. In parts of the Mississippi valley the common fire-fly is *Photinus pyralis*, which has brownish-black elytra margined with pale yellow, and a yellow prothorax with a black spot on its centre. The larva of *P. pyralis* lives in the ground, where it feeds upon soft-bodied insects and upon earth-worms (*Lum-*

bricus). *Photinus corruscus*, a species varying from 0.35 to 0.60 of an inch long, dull black in color, except two curved red lines extending from each side of the

anterior projection of the prothorax, which shields the head, back to near the posterior angles of the prothorax.

Among the insects of the sub-family Lycinae, of which the species are diurnal in habits, and wander about plants in search of insect food, *Coleopteron reticulatum* may be chosen as a representative. This species has the elytra gradually widening from the base to near the tip, and covered with a fine net-work or reticulate surface; its flat serrate antennæ and its under surface are black, as well as the middle of the prothorax, and the apical end of the elytra. In the form which was once known as *C. terminalis*, but which is now regarded to be a variety of *C. reticulatum*, the anterior two-thirds of the elytra are yellow, while in other specimens there is a patch of black near the base of each elytron. These insects vary from 0.40 to 0.75 of an inch in length. Their larvæ are clay-yellow, prettily marked with black, and are found under logs and stones, where they eat other insect larvæ.



The ELATERIDÆ, including with them the EUCNEMIDÆ and CEBRONIDÆ, which are often regarded as distinct families, comprise considerably more than three thousand species of described coleoptera, which are quite distinctly separated by a few marked characters, of which the following is an abstract from Drs. Le Conte and Horn's work, to which reference has been so often made: The antennæ are usually serrate, sometimes pectinate or flabellate, and are often inserted in grooves upon or under the front; the five (rarely six) ventral segments are free, and the first of them is not elongate; the hind coxæ are contiguous, and sulcate for the reception of the thighs; the front coxæ globose, and contained entirely within the prosternum; the prothorax loosely articulated to the mesothorax, and the prosternum prolonged behind. The greater part of the Elateridæ are popularly known in America as snapping-beetles and spring-beetles, and in England as click-beetles and skipjacks, because of their power of jumping up into the air when placed upon the back. Dr. Le Conte says this jumping "is effected by extending the prothorax so as to bring the prosternal spine to the anterior part of the mesosternal cavity, then suddenly relaxing the muscles so that the spine descends violently into the cavity, the force given by this sudden movement causes the base of the elytra to strike the supporting surface, and by their elasticity the body is propelled upward." Without the aid of this mechanism, these short-legged beetles would find difficulty in regaining their foothold when they had fallen on their backs, which might often occur, because of their habit of dropping to the ground, with legs retracted and feigning death, upon the slightest disturbance. If a beetle fails to regain his proper position by the first jump, the springs are repeated until success results, each spring, especially if upon a hard surface, is accompanied by a distinctly audible click.

The habits of the Elateridæ are quite diverse, many sit upon leaves of plants and upon grass, others are abundant under bark, and many species live concealed beneath stones. The larvæ usually live in decaying wood; some of them, however, do not confine their attacks to dead vegetable matter, but are known as seriously injurious to living plants and to cultivated crops; a few of these larvæ are carnivorous, the larvæ of *Drasterius umabilis*, in the United States, being known to devour locusts' eggs. Many elaterid larvæ, because of their cylindrical form and very firm, smooth, chitinous exterior, are known as wire-worms. The larvæ have six legs, no ocelli, and their antennæ are very short and three-jointed. Wire-worms have sometimes destroyed potatoes and cabbage roots by riddling them with their burrows. Some of these larvæ

develop under favorable circumstances in a year, but many of them require several years to attain full growth.

The Elateridae not only show their relationship to the Lampyridae by anatomical characters, but also by the possession of luminous organs in a few species, these luminous organs being found in the larvæ of a number of species, and being long since observed on the imagoes of *Pyrophorus*.

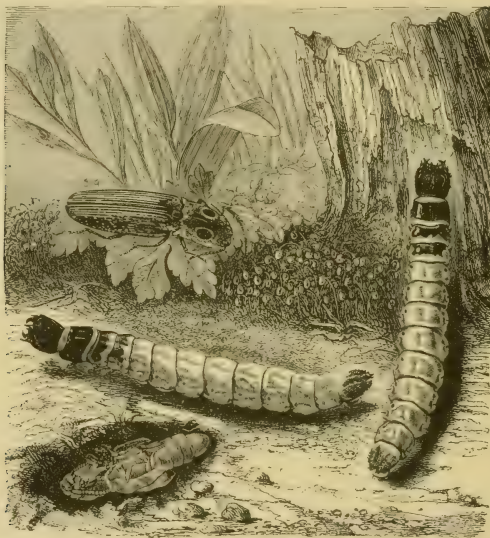


FIG. 413. — Stages of an Elaterid (*Abeus*).

The true Elateridae have the posterior coxæ laminate, and the labrum visible and free. *Melanotus piceus* is a very shining, black species, about one inch long, found upon the Atlantic coast of North America as far north as Massachusetts. *M. morio*, a somewhat smaller species with striate elytra, is found in the same regions. Larvæ, supposed to belong to *Melanotus*, are quite brilliantly luminous.

It is, however, to the genus *Pyrophorus*, which contains about a hundred species of Elateridae, all from tropical America, that we must turn for the most brilliant forms of luminous insects. *Pyrophorus noctilucus*, common in the West Indies and Brazil, and in common with a few allied species called the *cuengo* by the West Indians, is from 1.50 to 1.75 inches long. Its color is a rusty brown, approaching black. Upon each side of the prothorax, near its basal angles, is a convex, oval lantern, which,

when not illuminated, is yellowish white in color; but which, when illuminated, gives out a light exceeding in brilliancy that of the Lampyridæ. The species of *Pyrophorus* fly in much more direct lines and give out their light longer and more constantly than do the Lampyridæ. During flight a luminous organ situated beneath, between the metathorax and first abdominal segment, emits even more light than do the prothoracic lanterns. In Vera Cruz these beetles are so much used as toilet ornaments that they are an article of trade. The Indians capture them by waving about in the air a stick, to which they have attached a burning coal, the light of the coal attracting the beetles in the same way as they are attracted to each other by their own luminosity. They are preserved in boxes made of wire netting, are fed each evening with pieces of crushed sugar-cane, and are bathed twice a day in tepid water to keep them in good health. The emission of light by *Pyrophorus* seems, like that of Lampyridæ, to be entirely dependent upon the will of the insect; when feeding, and during sleep, no light is given off, the greatest intensity of the light being reached during flight and activity.



FIG. 414.—*Ludiis attenuatus*.



FIG. 415.—*Pyrophorus noctilucus*.

Corymbites is a large genus, numbering in the United States over seventy species, and the species vary greatly in form, size, and coloration. *C. resplendens*, common in northern New England, is shining bronze green with reddish reflections, and is about 0.5 of an inch long. *C. cylindriciformis*, a brown species which is quite elongated, varies in length from 0.45 to 0.80 of an inch.

The genera *Athous*, *Limoniis*, *Melanotus*, *Elatér*, and *Cryptohypnus* are all represented by numerous species in the United States, but many of these species are difficult to distinguish without elaborate descriptions or figures, and little is known of their life history. *Melanotus communis* is one of the most common species of snapping beetles in the northeastern United States; it is brown, pubescent, and about 0.5 of an inch long.



FIG. 416.—*Alaus oculatus*.

Alaus oculatus, not only on account of being one of the largest species of North American Elateridæ, but also on account of its peculiar markings, has attracted the attention of almost every beginner in entomology. Its length is a trifle over one and a half inches, and its coloration black and white. The two velvety black spots upon the prothorax, the white rings around these spots, and all the white dots scattered over this insect are produced by scaphoid scales densely set upon the surface. The larvæ of *A. oculatus* live in decaying wood, often in that of apple or pine, and are much broader proportionally than snapping-beetle larvæ usually are. The length of the larva of this species is 2.5 inches; its width about 0.4 of an inch across the middle of the body. The head is brownish, the rest of the larva reddish yellow.

The species of *Chalcopidius*, another genus of large snapping beetles closely allied to *Alaus*, are partly clothed with scales, as the generic name indicates. *C. rubripennis*, from southern California, is 1.5 inches long, the striate elytra reddish brown, the black prothorax converted to bronze green by a coating of microscopic scales.

The family of BUPRESTIDÆ includes a large number of beetles which somewhat resemble the Elateridæ, but differ from them in not possessing the power of springing when placed upon the back, and consequently they do not have the prothorax very freely movable upon the mesothorax. They also differ from the Elateridæ in having the first and second ventral segments connate. The eleven-jointed antennæ of the Buprestidæ are almost invariably serrate; the head is small and retractile to the eyes in the prothorax; the posterior end of the body is tapered off to a point; the ornamentation is usually with metallic colors, and the surface is often highly polished. In *Polybothris*, a genus found in Madagascar, the coloration during life is glistening metallic, which, as in *Cussida* of the Chrysomelidæ, disappears upon the death of the insect. The tropical species of Buprestidæ are often large, *Euchroma gigantea* from Brazil reaching a length of 2.75 inches, and a breadth of over an inch; the size of the species becomes gradually less in approaching the temperate and

FIG. 417. — *Euchroma gigantea*.

colder regions. These insects frequent flowers or sit upon bark, and are most active in bright sunlight; upon approach, many kinds fly away with great rapidity, others retract their short legs and drop to the ground, feigning death.

The larvæ of Buprestidæ usually bore elliptical passages in living and dead wood; a few, like those of *Trachys*, mine in leaves, and still fewer (e. g. *Diphucrania auriflua*) live in galls. The larvæ have a very characteristic form due to excessive enlargement and partial chitinization of the prothoracic segment, into which the head is retractile. There are no ocelli and no feet, the latter organs being represented in a few species by little fleshy tubercles; the antennæ are very short and formed of two or three joints. Larval life varies in duration; in *Trachys minuta*, which mines willow leaves, Rudow found two generations yearly; Perris found that many species completed their metamorphoses in a year, while Ratzeburg states that two years are occupied in the cycle of metamorphoses. Pupation takes place in the burrows made by the larva.

The small, flattened, ovate, somewhat angular species of *Brachys* are found upon leaves of different plants, and their larvæ are leaf-miners, like those of the related genus, *Trachys*. *B. tessellata* is only about 0.15 of an inch long, and nearly black in coloration; it is found in the eastern United States. *B. viruginosa*, a species of about the same size, and found in the same region, mines in the leaves of the beech.

FIG. 418. — *Brachys tessellata*.

The numerous species of *Agrilus* are elongated, and have the antennæ free, not received in grooves as in *Brachys* and *Trachys*. *Agrilus ruficollis* is quite injurious to raspberry and blackberry patches in the eastern United States. The beetle is narrow, about 0.25 of an inch long; its head and thorax is a beautiful coppery bronze, the elytra are black. The larvæ, which are about 0.5 of an inch long, and pale yellow, with a brownish head and black mandibles, bore about in the sap-wood of the black-

berry and raspberry stalks, until they reach full growth, when they pupate in the pith. Their presence in stems of the plants can be readily detected by the gall-like swelling that they produce. On account of the spiral course of the burrows of the larvæ, the part of the stalk above these galls generally dies. The best mode of destroying these insects is to burn, during early spring, the stalks which have galls upon them.

The species of *Aemoderus* are not as elongate as those of *Agrius*, and their scutellum is indistinct. *Aemoderus culta*, a black species with yellow spots on the elytra, and only 0.25 of an inch long, is common in eastern North America, on the flowers of star-grass (*Hypoxys erecta*). *A. gibbula* is a western form.



FIG. 119.—*Aemoderus culta*.

A large number of species of medium-sized Buprestidae which are of a dark green, coppery, or black-shining bronze color, and are covered with impressed dull spots, are grouped in the genus *Chrysobothris*. Of these species *C. femorata*, a greenish-black



FIG. 120.—*Chrysobothris femorata*.

species that varies from 0.4 to 0.6 of an inch in length, and two-thirds as wide, besides being, as larva, injurious to oaks and other forest trees, damages peach and pear trees, and often causes serious fatality to apple trees. These beetles are found from May until the end of summer. Their pale yellow, thin-shelled, ribbed eggs are laid, singly or a few, in groups, in crevices of bark. The young larvæ, upon hatching, bore into the bark and live beneath it, in flattened channels, soon girdling small trees. Later, as its jaws become stronger, it attacks the solid wood, but always again comes to the surface before pupation. After cutting a passage almost through the bark it retreats, packs its debris and excrement about it, and pupates. Upon emergence, the beetle, which has feebler jaws than its larva, has no difficulty in reaching the open air. *C. harrisii*, one of the smallest beetles of this genus, being only about 0.3 of an inch long, is a somewhat rare but brilliant species. Its larva lives in pine twigs, and the brilliant metallic-green beetle may be found, during June and July in New England, sparkling in the hot sunlight on the tips of white-pine boughs; on account of its shyness and rapid flight it is not easily captured.

Similar in form to *Chrysobothris*, but having a broader front, is *Melanophila*. *M. fulvoguttata*, of a brassy black color from 0.30 to 0.45 of an inch long, has three yellow dots upon each elytron. This species frequents pines throughout the northern United States.



FIG. 121.—*Melanophila fulvoguttata*.

In *Buprestis*, a genus numbering, as at present limited, over fifty species, many of which are beautifully colored, the beetles are rather larger than in the preceding genera. *B. rufipes* is a North American species, of which the earlier stages

are unknown. *B. fasciata* is one of the most brilliant species of this genus. It is from 0.60 to 0.75 of an inch long, of a brilliant metallic-green with golden reflections, with a small yellow spot near the tip of each elytron, and a band of yellow nearly across each elytron just in front of the apical spot. The larva probably feeds in willow or pine wood, and it inhabits the northern United States.



FIG. 122.—*Buprestis rufipes*.

Dicerca divaricata, which is of a coppery-bronze color and about 0.75 of an inch long, is easily recognized by the prolonged and divergent tips of its elytra; it is common in the eastern United States. Its larva attacks peach, maple, cherry, and beech trees.

The species of *Chalcophora* resemble, in form and mode of indentation of the

elytra, the species of *Chrysobothrys*, but are generally larger and have a distinct sixth ventral segment. *C. liberta*, from the eastern United States, is light copper-bronze in color, the elevated portions of the surface being polished while the depressed parts are dull. It feeds, as larva, in pine woods, as does also *C. virginiensis*, which is generally a little darker colored and somewhat larger; the former species is from 0.75 to 1.10 inches long. The larvæ of both species inhabit pine wood. *Gyascutus* and *Psiloptera* are genera only represented by a few large species, from western North America, of which the earlier stages are unknown; they are separated from *Chalephora* by their having the mentum rounded in front; they are distinguished from one another by the first joint of



FIG. 423. — *Chalephora virginensis*.

the posterior tarsi being elongated in *Gyascutus*, and not elongated in *Psiloptera*. Near these genera in classification are the giant South American species of *Euchroma*, of which *E. gigantea* has been already mentioned, and the brilliant oriental and African species of *Chrysochroa*, the latter generic name being compounded from two Greek words meaning "gold" and "skin." *Chrysochroa ocellata*, a large species from the East Indies, is beautiful shining green, with elytra marked with golden and yellow spots, and three-toothed at the apex. *Sternocera*, another Asiatic and African genus, contains large and brilliant species, in which the sternum is prolonged forward and downward as a horn. *Sternocera chrysis*,



FIG. 424. — *Gyascutus planicosta*.

a large species with chestnut-brown elytra, lays elliptical white eggs that are 0.36 of an inch long and 0.24 of an inch in shorter diameter, and from which the larvæ at hatching are about 0.45 of an inch long.



FIG. 425. — *Chrysochroa ocellata*.

The described species of SCARABÆIDÆ number over seven thousand. They are readily separated from all other Coleoptera by the form of their antennæ, in which the outer joints—usually three, sometimes as many as seven in number—are flattened lamellæ capable of close approximation to form a club, and by their fossorial legs. The antennæ, which are inserted beneath the sides of the front, have from seven to eleven joints; the first joint is always elongated, and the second thicker than the third. On account of the form of their antennæ, beetles of this family are often called lamellicorns. There are no very minute species of Scarabæidæ; the family, on the other hand, contains some extremely large insects, the veritable elephants among Coleoptera. The lamellicorns, of course, reach their greatest development, both as to number and size of species, in the tropics, but species of considerable size are not wanting in the temperate zone. These beetles attract the attention of people not generally interested in natural history, not only on account of their large size, but also because of their curious habits, sometimes useful to man, as are those of the dung-beetles, one of which (*Ateuchus sacer*) was long recognized as sacred by the Egyptians.

Quite a number of genera are wingless, although the greater part can fly. A large number produce sounds, either by stridulation, by the motions of the wings, or in some cases by the rapid passage of air in or out of the stigmata. Sonification is not confined to imagos, for many lamellicorn larvæ stridulate by rubbing the maxillæ against the

mandibles. The imagoes of one portion of this family are mostly vegetable feeders, often living upon leaves; those of another portion feed upon the excrement of higher animals; a few eat fruit, flowers, or honey, even, exceptionally, entering beehives to steal honey; certain species also lick the sap from wounded places on trees; and a very few (e.g., *Tene*) feed upon decaying animal matter. In their sexual relations, some species of lamellicorns have strange habits. *Elaphocera bedouti*, a common species in the sand dunes of the Bay of Cadiz, copulates only during storms; at other times the beetles remain concealed in the sand. In *Bolboceras gallicus*, a French species, the two sexes inhabit neighboring burrows a foot deep in the ground, and the male digs a passage out from his own burrow to that of the female. The males of *Polyphylla variolosa*, from the eastern United States, have been seen vigorously scratching the ground above places where females were about to emerge from their pupæ, presumably guided to them by the sense of smell, a sense which has reached a high degree of development in the lamellicorns. The aid which certain male dung-beetles give the females in their maternal duties will be more fully noticed further on. The males of lamellicorns are usually much larger than the females, and are often easily distinguishable from the latter by horns upon the prothorax or head, by better-developed antennæ, or by modifications of the legs.

The larvæ of the Scarabæidæ are rather robust, white grubs. Their anal end is curved around under their body so that they cannot walk on a flat surface, but are only able to use their six well-developed legs in locomotion when surrounded by the substances in which they live. The head is corneous and resistant, with four-jointed antennæ and without ocelli. The rest of the larva is covered with a somewhat tough skin, and widens posteriorly so that the apical half of the abdomen is broader than its base. All lamellicorn larvæ live concealed, some in the ground, feeding upon roots, others in decaying wood, in excrement, or in other substances which they devour. The coprophagous species undergo their metamorphoses rapidly, but the other lamellicorns often require two or three years to pass from the egg to the imago. Several nematode worms inhabit the capacious digestive tract of certain lamellicorn larvæ; but, besides these, the larval stage of *Echinorhynchus gigas*, an acanthocephalous worm which lives as adult in the intestinal canal of swine, has been found in the grubs of the European May-beetle (*Melolontha vulgaris*). The swine eat the May-beetle grubs, thus infecting themselves with worms, and the dung of the swine furnishes the May-beetle grubs the eggs of the worm—a curious interrelationship between hog, worm, and insect. The larvæ of certain lamellicorns are subject also to fungus parasitism by species of *Torrendia*, of which the fructification stems grow out from the grubs killed by the fungus, often to the height of several inches, giving rise to stories of grubs changing into plants.

Dr. Le Conte has divided the Scarabæidæ into three sub-families, according to the position of the abdominal stigmata. In the lowest sub-family, the Scarabæidæ pleurosticti, the abdominal stigmata (except the anterior ones) are "situated in the dorsal portion of the ventral segments, forming rows which diverge strongly;" the last pair of stigmata is visible behind the elytra.

Osmodendia has the thorax considerably narrower than the elytra and usually rounded at the sides; the posterior coxæ are contiguous, and the outer lobe of the maxillæ is corneous. *O. scabra* is about 0.9 of an inch long, with a roughened but shining coppery or brownish-black surface. Its larva lives in decaying rosaceous wood, and pupates in an oval cocoon made by cementing together fragments of the

wood in which it feeds. *O. crinita*, a slightly larger, smooth, dark-brown species, has habits similar to those of *O. scabra*. Not far from *Osmodecut* in classification is *Inca*, the species of which are found in tropical America, and are large and bronze colored.

In the species which belong to the old genus *Cetonia*, which is now subdivided into numerous genera, the scutellum is visible, the mandibles are feeble and often membranous, the epimera of the mesothorax is visible from above, and the anterior coxae prominent. During flight the elytra of these beetles remain closed, the wings extending out from beneath the base of the elytra. Some of the species eat honey, others soft fruits, still others lick sap from wounds of trees. Thus the mandibles, having no hard work to do, are feeble. *Tropinota hirtella*, a small European species which is black, somewhat marked with white, and densely pubescent with brownish hairs, injures fruit-blossoms by eating away their anthers and styles.

Eurygonia inda is the most abundant species of cetonian in the northeastern United States. It is about half an inch long, light brown, marked with irregular black spots. Its thorax is covered with yellowish pubescence. This beetle has been found feeding upon the kernels of young corn; but it is doubtful if the beetles, with their soft mouth-parts, are really guilty of attacking the corn. It seems more probable that they only eat the juices of kernels which have been already bitten into by birds or by other insects. These beetles are, however, known to eat into ripe peaches, and to feed upon the sap from corn-stalks and from cotton-bolls. I have found the



FIG. 426. — *Eurygonia inda*.

same species very abundant, devouring sap which exuded from wounds in the bark of oak trees; and I presume that, in their reported attacks upon apple-tree bark, they are only eating the sap flowing from wounds caused by other animals. This species is found in early spring, before the snow is all melted from the ground, making as much noise as bees and buzzing about in warm sunny spots. This beetle has a peculiar acid odor, resembling vinegar, when handled. This acid is probably readily volatile, as it does not rust, to any great extent, the pins used in mounting these insects in collections. *Cetonia aurata*, a common metallic-green European species, is also quite odorous. The larvae of *E. inda* are not yet known.

Allothina nitida is nearly an inch long, velvety green usually with a yellowish margin along the sides of the prothorax and elytra, and is abundant in the southern part of the Atlantic slope of the United States. Its larva, according to Dr. C. V. Riley, attacks strawberry roots; and, because its curved body would cause it to travel clumsily on its legs, it turns over upon its back and moves along as rapidly as an ordinary caterpillar.

The cetonians attain their maximum size in the genus *Goliathus* from western Africa. *G. giganteus* measures about four inches in length and two inches in width, and is one of the largest beetles known. This species is subject to considerable variation, and several varieties have been described as species. It is usually chalky white, marked with velvety black, prominent among the black parts being six black lines radiating from near the anterior part of the prothorax towards its posterior part. These giant beetles live upon the sap of trees.

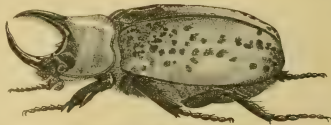


FIG. 427. — *Dynastes titus*, male.



Dinastes hercules, Hercules beetle, male and female.

The genus *Dynastes* includes, in another group of beetles, even larger species than are those of *Goliathus* among the cetoniids. In *Dynastes* the tarsal claws are equal and the anterior tarsi elongated, the anterior coxae transverse and not prominent, the prothorax and head armed with horns or tubercles. *D. titus* is one of the largest, possibly the largest, species of Coleoptera found in the United States, and occurs in the southern part of the country as far north as Philadelphia. It is about two inches long and one inch wide; is of a general greenish-white color, with black legs and brownish black spots upon the elytra. In the males the anterior portion of the prothorax is provided with a downward-curved black horn that approaches at its tip a similar upward curved horn from the head. The larvae of this and other species of *Dynastes*



FIG. 428. — *Megasoma elephas*.

live in decaying wood. *Dynastes hercules*, from tropical America, reaches a length of six inches, of which the curved prothoracic horn makes nearly one-half. The elytra are light olive green, spotted with black; the rest of the beetle is shining black. The prothoracic horn is lined with yellow hairs beneath; and below it, as in *D. titus*, is a shorter upturned horn from the head. The articulation between the prothorax and head allows these horns to be separated and brought toward each other like the two halves of a pair of forceps. *D. neptunus*, a species of about the same size as is *D. hercules*, also inhabits tropical America. Closely allied to *Dynastes*, but separated from it by its glabrous prosternal process, is *Megasoma*. *M. elephas*, *M. typhon*, and *M. actron* are all large species from Central and South America. *M. thesites* is a Californian species.

The genera *Strategus*, *Xyloryctes*, and *Oryctes* comprise species not quite as large as those of the foregoing genera, having horns or tubercles on both sexes, and with the anterior feet not elongated. In *Strategus*, the prothorax usually has three horns in the males and three tubercles in the females. *S. antæus*, a shining dark-brown species about an inch in length, is found near the Atlantic coast of the United States as far north as Massachusetts.



FIG. 429. — *Oryctes nasicornis*.

In *Xyloryctes*, the head is horned in the males and tuberculate in the females. *X. satyrus*, which is deep brown, has striate elytra, and is a little over an inch in length, resembles *Oryctes nasicornis*, a common European species. *X. satyrus* is found in the same regions as is *Strategus antæus*. *O. nasicornis* frequents tanners' refuse used to surround hot-beds in northern Germany.

Cotalpa has the claws of the tarsi unequal, the elytra without a membranous margin, the thorax margined at the base, the clypeus separated from the front by a suture, and ten-jointed antennæ. *C. lanigera*, the so-called goldsmith beetle from eastern North America, is nearly an inch long, and light yellow in coloration. The female lays her eggs singly in the ground. The eggs are waxy white, semi-transparent, and oval, and measure about 0.1 of an inch in length. The larva, upon hatching, is about 0.3 of an inch long. It probably requires two or three years to reach full growth, feeding, meanwhile, upon roots of plants. Pupation finally takes place in an oval subterranean cavity. The imago frequents many kinds of trees, but is especially fond of willows, among the leaves of which it nestles during the day, since it is nocturnal in habits.

In *Pelidnota* there is no suture between the clypeus and the front. *P. punctata* is a well-known beetle about grape-vines in the eastern United States. It is brownish yellow above, marked with black as follows: the posterior and lateral portions of the head, the scutellum, a dot upon each side of the prothorax, and three dots near the outer margin of each elytron. Beneath, the body and the legs are shining greenish black. The larva of this species lives in the decaying roots of trees, but is with difficulty distinguished from other lamellicorn larvæ. These beetles fly mostly at night, remaining concealed about grape-vines during the day. They eat grape-leaves and those of *Ampelopsis*, but are rarely abundant enough to do real damage.



FIG. 430. — *Pelidnota punctata*.



FIG. 431. — *Anomala lucicola*.

Separated from *Cotalpa* and *Pelidnota* by the possession of nine-jointed antennæ and by having elytra with a membranous margin are the species of *Anomala*, of which *A. lucicola* is a serious foe to grape-culture in some parts of the United States. Its colors are somewhat variable, some specimens being yellowish brown, others black, and still other combinations of these two colors. The larvæ of *Anomala* have not been carefully studied. The beetles often eat away the flower-buds and blossoms of the grape, and also are very abundant upon flowers of species of sumac (*Rhus*). In Europe *A. vitis* and other species damage grapes.

Herodon montandoni is a curious oval species, about 0.6 of an inch long, which

inhabits Madagascar. Its form and the pattern of its coloration, the elytra being black striped with white, recall those of the Chrysomelidae. Its life history is unknown.

The second sub-family of the Scarabaeidae, the Melolonthinae, have the abdominal stigmata "in part situated on the superior portions of the ventral segments, the last one usually visible behind the elytra." The rows of spiracles diverge slightly.

In *Polyphylla* the club of the antennae is many-jointed, and in the males is very large, the third antennal joint is long, the lateral pieces of the metathorax are wide, the anterior coxae are not prominent, the last pair of stigmata open in the suture between the fifth ventral segment and the pygidium. *P. variolosa*, found abundantly in parts of the United States, is nearly an inch long, and is brown covered with small irregular patches of white. *P. fullo*, the largest European May-beetle, frequents sandy plains covered with conifers. Its length is from 1.25 to 1.50 inches, its color chocolate brown, spotted with irregular patches of white scales and hairs.

Melolontha closely resembles *Polyphylla* and is represented by quite a number of species in the eastern hemisphere. *M. vulgaris*, the common May-beetle of Europe, is about an inch long, and the antennal club of the males is composed of seven lamellae, while that of the females has only six shorter lamellae. The pygidium is prolonged into a sharp point. In the common form the antennae, legs, and elytra are brown, the rest of the insect being black, and different parts are more or less densely clothed with fine white scales or hairs. On the lateral parts of the abdominal segments these hairs are so dense as to produce a white triangular spot upon the side of each segment. Varieties are numerous. The metamorphoses of *M. vulgaris* require three or four years, according to climate, and their appearance in large numbers is periodical. Reiset writes that in 1865 the beetles defoliated the oaks and other trees in parts of France. The next year the young larvæ hatched from these beetles devoured the roots of garden vegetables so extensively that the loss in the department of the Lower Seine was estimated at over five million dollars. These larvæ passed the winter of 1866-7 at about sixteen inches beneath the surface of the ground. A thermometer kept in the ground at the same depth indicated that the larvæ must have been frozen during the winter, thawing out again in the spring. In June, 1867, the full-fed larvæ pupated about a foot below the surface, emerging as beetles during October and November of the same year. These beetles, however, remained in the ground until April and May of the succeeding year (1868), thus, in France, completing their metamorphoses in three years. The tufted lark (*Alauda cristata*) is said to feed its young almost exclusively with larvæ of this and of related lamellicorns, thus doing good service to agriculturists.

Lachnosterna differs from *Polyphylla* in having the lateral pieces of the metathorax narrow and the third antennal joint not elongated. There are many species of this genus on the Atlantic slope of North America, while only two species are known from the Pacific slope. *L. fusca* (often mentioned as *L. quercina*) is very common in parts of the United States and Canada; it is about 0.9 of an inch long, and of a dark-brown color. The beetle, which is often called the June-bug, attacks the leaves of various trees, having a preference for those of plum and cherry. The larva, known as the white grub, lives upon roots, and has habits quite similar to those of *Melolontha vulgaris* in Europe. Turf is often ruined by larvæ of *L. fusca* associated with other larvæ of the genus, and they sometimes cut off strawberry roots. *Tiphia inornata*, a hymenopterous parasite, has been reared from these larvæ. In Europe numerous species of *Rhizotrogus*, a genus very similar to *Lachnosterna*, are termed June-bugs.

One of the best-known species of lamellicorns in the eastern United States is *Macrodactylus subspinosus*, erroneously called the "rose-bug." It is about a third of an inch long, of a dull yellow color, and has long brown legs. These beetles appear in June, often suddenly and in immense numbers, and devour roses, and the flowers and young fruit of grapes, apples, pears, cherries, and many rosaceous trees. They are also abundant upon flowers of sumac (*Rhus*), elder, ox-eye daisy (*Leucanthemum vulgare*), and species of *Spiraea*; but when the above-mentioned plants fail, they will eat almost any kind of green vegetation. Their most serious injuries to agriculture consist in their eating fruit-blossoms and young fruit, although they have been known to strip the leaves from fruit-trees and grape-vines. In 1825 the Massachusetts State Board of Agriculture offered a premium for the best essay on this insect, its natural history, and efficient means of destroying it. Dr. T. W. Harris, the well-known entomological writer, was awarded the premium for an essay, from which the following account of the life history of this insect is condensed: Each female deposits about thirty nearly globular whitish eggs from one to four inches beneath the surface of the ground. The larvæ hatch in about twenty days, and immediately begin to feed upon tender roots. They attain full size in autumn, being then nearly 0.75 of an inch long, and about 0.12 of an inch in diameter. They are of a yellowish-white color, with a tinge of blue towards the hinder extremity, which is thick, and obtuse or rounded. In October they descend below the reach of frost, and pass the winter in a torpid state. In the spring they again come near the surface of the ground, where, in May, they pupate in little oval cells, the beetles emerging in June. The most practicable mode of capturing these beetles, when they attack fruit-trees, is to shake or jar the trees, after spreading sheets beneath them. This should be done, as suggested by

Mr. J. A. Lintner, in the cooler parts of the day when the beetles, which are always clumsy, are quite inactive. The captured beetles may be killed by scalding, and fed to chickens.



FIG. 432. — *Serica respertina*.

The genus *Serica* contains quite a number of robust brownish species, with striate, often iridescent, elytra. The last pair of abdominal stigmata are in the fifth ventral segment, which is separated by a suture from propygidium. The labrum is connate with the clypeus. *S. respertina* is common, during June, in New England, upon the sweet-briar rose. It is light brown in color, and from 0.3 to 0.4 of an inch long. With it may be found usually *S. sericea*, a very dark-brown iridescent species, of about the same size.

In *Hoplia* the last pair of stigmata is between the fifth ventral segment and the propygidium which are connate, the middle coxæ are contiguous, and the tibiæ have but one spur. The species are usually found on flowers, and the sexes often differ greatly. Most of the species are more or less clothed with scales; and the *H. cœrulea*, a European species, is of a beautiful metallic blue, due to shining scales covering its otherwise brown surface.

The species of *Lichnanthe* are hairy insects, with poorly developed elytra, which are divergent at the tips, and do not reach the tip of the abdomen. *L. vulpina*, distributed throughout the United States, is about 0.5 of an inch long, dark brown, and nearly the entire surface except the elytra is densely clothed with long, light-brown hair.

In the third sub-family of the Scarabæidæ, the Scarabæidæ laparosticti, the abdominal stigmata are situated in the membrane which connects the dorsal and ventral

segments, the posterior pair of stigmata being covered by the elytra. The antennae have from nine to eleven joints, of which the outer three only, in all genera except *Phocomit*, form a compact club. The species of this sub-family mostly live in excrement, a few in other decomposing matter.

The species of *Trox* have five ventral segments visible, and the epimera of the mesothorax do not reach the rounded coxae. The numerous North American species of this genus are oval beetles, mostly with rough surface. They feed upon dried decomposing animal matter, and many species are found about the refuse of tanneries, and upon the hoofs and hair of decaying animals.

The species of *Geotrupes* have the antennae eleven-jointed with lamellate club, the mandibles well developed, and the abdomen exposing six ventral segments to view. Most of the species are black, some with a bluish or greenish tinge; a few species have brilliant metallic coloration. The elytra are usually striate, the prothorax sometimes armed with horns or tubercles, as in *G. typhlocus*, a species common in Europe. The larvæ of *Geotrupes* develop in masses of excrement which the parents bury in the ground, and in each of which the female deposits an egg. Seven species of this genus have been described from North America. Several of them are quite common, and can be found by digging in the earth about cow-dung during late summer and autumn.



FIG. 435. — *Geotrupes typhlocus*.



FIG. 434. — *Aphodius fossor* and larva.

The large genus *Aphodius* numbers over fifty described species in North America. Their antennae are nine-jointed, the posterior tibiae have two spurs, the front tibiae are strongly toothed on the outer margin, the epimera of the metathorax are not visible, and the elytra are striate. The species of this genus are mostly of small size, *A. fossor* being one of the largest species. Their larvæ feed in excrement and develop rapidly. Heeger found that the larvæ of *A. foetens*, a common European species, hatched from the egg in from ten to twenty days; the larvæ moulted three times, attaining full growth in from four to five weeks; and pupation lasted from fourteen to twenty days. Chapman observed that *A. porcus*,

another European species, destroys the eggs of *Geotrupes stercorarius*, and uses the passages of the latter insect for its own oviposition. Species of *Aphodius* have been found near the crater of Vesuvius, where the sandy lava had a temperature of 182° F.

Six of the species of *Aphodius* that are found in the United States were introduced from Europe. Among these *A. fossor* is large and entirely black; *A. bimaculatus* is about 0.3 of an inch long, and black with red elytra; and *A. inquinatus* is about 0.2 of an inch long, black, with portions of the elytra yellowish.

Among the dung-beetles of robust form and moderate or small size, the genus *Onthophagus* includes a large number, of which but a few are found in North America. They have nine-jointed antennae and no scutellum, the third joint of the labial palpi is obsolete, and the distal end of the middle and of the posterior tibiae is dilated. One of the commonest kinds in the eastern United States is *O. latroscus*, a brownish black species about 0.25 of an inch long and nearly 0.20 of an inch wide. From the posterior end of the prothorax to the front of the head is over one-half the total length of this insect. In the males a broad, almost bi-lobed, horn extends out from the fore part of the prothorax and shelters the head.

The species of *Phanaeus* are sometimes of considerable size, and are often of metallic or bronzed coloration. They have broad three-jointed labial palpi, the anterior coxæ short but prominent, and the first joint of the antennal club is hollowed out to receive the other two joints. *P. carnifex*, from eastern North America, frequents human excrement, especially when left in sandy places. Its prothorax is coppery bronze, its elytra metallic green; both are roughened, the latter being also striate. In the males the head supports a horn, which curves gently backwards, and, when long, rests between two slight elevations on each side of the prothorax. In *P. damon*, from Mexico, these elevations on the prothorax are prolonged into wing-like processes, while the cephalic horn is largely developed.

Copris differs from *Phanaeus* in having the lamellæ of the antennal club alike.



FIG. 435. — *Ateuchus variolosus*, surrounded by scarabæi.

The species are black, with densely punctate prothorax and striate elytra, and the elypeus is broadly expanded and covers the mouth-parts. The males generally have a horn upon the head and tubercles upon the prothorax. *C. carolina*, a species about an inch long and 0.7 of an inch wide, is found along the Atlantic coast of the United States as far north as Massachusetts. *C. anaglypticus*, a species about 0.6 of an inch long, and *C. minutus*, about 0.4 of an inch long, are found in the eastern United States.

Species of *Canthon*, *Ateuchus*, and allied genera are remarkable for their peculiar mode of rolling about a globular mass of dung, in which they finally deposit an egg, and then bury in the ground. *Canthon* is distinguished from *Copris* by its having slender curved middle and hind tibiæ; the head and prothorax are hornless in both sexes; the epipleuræ are narrow. *C. brevis* is a common species in parts of the United States. It is from 0.5 to 0.6 of an inch long, nearly smooth when examined only with the naked eye, and of a dull-black color.



SCARABÆID BEETLES.

1. *Hezodan montandoni*. 2. *Canthon hudsonius*. 3. *Osmoderma scabra*. 4. *Phyllophaga fusca*. 5. *Onthophagus maurus*. 6. *Iuca chalybeatus*. 7. *Lichnanthe vulpina*. 8. *Cotelpra lanigera*. 9. *Alouschus suer*. 10. *Phanaeus carnifex*. 11. *Copris carolina*.

At the head of the Scarabæidæ stands *Ateuchus* (or *Scarabæus*) *sacer*, the *scarabæus* of the ancients, of which figures are found carved in stone on the monuments of ancient Egypt, and which is often termed the sacred beetle of the Egyptians. It is a somewhat flattened, dull-black beetle, a little over an inch in length. Its elytra are scarcely striate, although some of the beetles carved by the early Egyptians had elytral striæ, and may have been made with *Ateuchus laticollis*, an allied species, for a model. The species of beetle which the Egyptians intended to represent is known not only from their representations, but from specimens preserved with mummies. These beetles dig out pieces of the excrement of various mammals, using their shovel-formed head for the work. With their legs they form these masses of excrement into a ball, which they gradually increase in size until it is nearly two inches in diameter. Now begins the curious process of rolling this ball to a hole, a foot or more in depth, which has been made for its reception. One of the beetles pushes the ball from behind, seizing it in his hind legs, which are fitted for the purpose by their curved tibiae, and, with lowered head, moving backwards. Another beetle aids by pulling at the opposite side of the ball, using the fore-legs as hands. Thus rolled along, the ball, at first plastic and irregular, is covered with particles of earth, and acquires solidity and an almost perfectly spherical form. This ball, which contains a single egg and excrement just sufficient to feed the larva during its growth, is put into the hole in the ground, and the hole filled with earth, after which the parent insects go about repeating the process of making more balls. As each ball is the nest for only one of their offspring, the industry with which these beetles labor for the propagation of their kind is remarkable. They are not rare near the coast around the whole Mediterranean, and their value as scavengers is considerable. But what happens within the balls which they bury? The egg hatches, the larva eats the food-supply so carefully stored away by its parents, pupates, and the next season emerges as imago.

All the subterranean metamorphoses of these sacred beetles remained unknown to the Egyptians, who considered them as generated by males alone, for they supposed that all these beetles were males. With the Egyptians, as Kirby and Spence write, this beetle was a symbol "of the world, as P. Valerianus supposes, on account of the orbicular form of its pellets of dung, and the notion of their being rolled from sunrise to sunset; of the sun, because of the angular projections from its head resembling rays, and the thirty joints of the six tarsi of its feet answering to the days of the month; and of a warrior, from the idea of manly courage being connected with its supposed birth from a male only. It was as symbolical of this last that its imago was worn upon the signets of the Roman soldiers; and as typical of the sun, the source of fertility, it is yet, as Dr. Clarke informs us, eaten by the women to render them prolific."



FIG. 436. — *Lucanus taurus*.

The LUCANIDÆ differ from the Scarabæidæ but little in structure. They are lamellicorn Coleoptera, in which the lamellæ of the antennal club are not capable of being brought compactly together. The pygidium

is always covered by the elytra, and the beetles are usually somewhat elongate. Although the species belonging to this family are generally nearly monochlorous—usually shades of brown in temperate regions—in tropical species the colors are often greater in number. Some of the species have stridulating organs. The larvæ of the Lucanidæ resemble closely those of the Scarabæidæ; they live in decaying wood, on the juices of which the imagos also feed.

In *Lucanus* the mentum is entire, and covers the ligula and maxillæ, the antennæ are geniculate, the eyes emarginate, the anterior tibiæ toothed on the outer edge. *L. dama*, from the eastern part of North America, varies from 0.9 to 1.5 inches in length. It is of a dark chestnut-brown in color, and the mandibles of the male, as is usual in species of *Lucanus*, are much enlarged, and have a single tooth on the inner side. *L. elaphus*, whose mandibles are branched in the male, and often 0.75 of an inch long, is called, on account of its antler-like mandibles, the stag-beetle. It closely resembles *L. verrus*, the European stag-beetle, which latter is, however, somewhat larger. The larvæ of *Lucanus*, which inhabit dead wood, have six well-developed legs, antennæ of four joints, and the anus in a longitudinal cleft.

Differing from *Lucanus*, in having an emarginate mentum, are the species of *Pasalus*, which are numerous in some tropical regions, but of which only one is found in the United States. This species, *P. cornutus*, is flattened, cylindrical in form, about 1.25 inches long, and of a very dark-brown color. Its surface is highly polished, the prothorax being smooth, the elytra striate. These beetles, with their white larvæ, are often found in great numbers in half-decayed logs, and when taken between the fingers emit a peculiarly delicate squeaking sound. Their larvæ are readily recognized by their very poorly developed posterior legs. They further differ from those of *Lucanus* in having a slenderer form, three-jointed antennæ, and the anus in a transversal cleft. The intestines of *P. cornutus* furnish a rich field for the microscopist. Prof.



Joseph Leidy has described protophyta, protozoa, and nematode worms from this insect.

The PARNIDÆ include a small number of beetles which are united in one family more by their resemblance as larvæ than by the structure of their imagos. The beetles have in common the following characters: the dorsal segments of the abdomen are partly membranous, the first to the third ventral segments are connate, the last joint of the tarsi is long and the claws large. The body is very finely pubescent, and a film of air adheres to this pubescence when the beetles are beneath the surface of water, for they are all aquatic in habits.

The larvæ of the Parnidæ are, according to Friedenreich, flattened oval in form, and most of them adhere to stones under water by using their entire ventral surface as a sucker. They consist of twelve segments, of which the first one later forms the head and prothorax of the imago. The aquatic species have closed stigmata, and respire by gills, from which air is distributed through a closed tracheal system. The gills are tubular, and consist of a motile trunk, to which are attached filamentous branches. These gills are beneath the fourth to the ninth or the fifth to the tenth segments, and have no relation to the stigmata. The internal tracheæ are moulted through the closed stigmata. One species which lives in moist air has eight pairs

of perforate stigmata. Pupation takes place beneath the flat oval shell of the larva.

In *Psiphentus* the abdomen has more than five ventral segments. *P. lecontei* has a wide distribution over the eastern United States. Mr. H. G. Hubbard writes of this species: "The males and unimpregnated females are very active, and in the heat of the day collect upon stones in mid-stream, which barely break the surface of the water, and are occasionally washed by a ripple. Over these stones they run in ceaseless activity, chasing each other like flies at play, and making occasional short flights over the surface of the water, but never plunging beneath it, nor suffering themselves to be submerged even for an instant. They are at such times exceedingly wary, and, unless approached very cautiously, they vanish before the observer can get near enough to use his net. They leave the stone with a flight so swift that it cannot be followed with the eye, but they will invariably be found all together and



FIG. 438. — *Psiphentus lecontei*.

at play upon another stone at no great distance. The gravid females are found in July or August engaged in laying their eggs on the underside of submerged stones in shallow brooks. When so engaged they are very sluggish, and never attempt to escape. The eggs are of a bright orange color, and are deposited in irregular clusters." The larva of this species, which is very abundant in some streams, is especially common in the rapids above Niagara Falls. This larva was originally described as a crustacean under the generic name of *Fluviicola*.

Elmis has only five ventral segments and rounded anterior coxæ. *E. condimentarius* is said to be used in Peru for flavoring food.



FIG. 439. — *a*, *Anthrenus muscorum*; *b*, *Ptinus fur* (see page 356); *c*, *Attagenus pellio*; *d*, *Dermestes lardarius*.

The DERMESTIDE are small oval or elongate beetles, some of which are the most troublesome insects of houses and storerooms. Systematically they are recognized, according to Le Conte and Horn, by their having the dorsal segments of the abdomen partly membranous, the ventral segments free, the mentum moderate or small, the palpi approximate at the base, the posterior coxæ not prominent, the antennæ moderate in length and capitate, the body usually scaly or pubescent. Most of the

genera (except *Dermestes*) have an ocellus on the front. These beetles, together with their larvæ, feed upon a variety of substances, both animal and vegetable. Some of the species are the most dangerous of museum-pests; others attack food in the pantry, store, or warehouse; drugs do not escape their attack, species devouring even cantharides and tobacco; woollen and silk goods, feathers, and furs are ruined if left long exposed to their depredations; and one species is accused of biting young doves. The *Dermestidae* feign death, and do it so skilfully and for so long a time that they are sometimes left for dead, only to escape and renew their depredations. Their oval larvæ, which do more injury than the beetles, are usually covered with long brown hair, and in some cases these hairs are beautiful spear-like objects for microscopical examination. The larvæ moult a larger number of times than is commonly the case with beetle larvæ, probably eight or more times.

Dermestes lardarius, the bacon-beetle, which is about 0.3 of an inch long, is brownish black, except the anterior half of the elytra, which are gray, spotted with black. This beetle has become cosmopolitan. It eats wool, silk, hair, horn, hoofs, and other substances, and often attacks neglected collections of insects. Its larva is about 0.45 of an inch long, and tapers somewhat from the anterior toward the posterior end. This larva was first described by Goedart, in 1667, and has been redescribed since that time by many entomologists.

The species of *Attagenus* are generally smaller and less elongated than those of *Dermestes*. They have an ocellus on the front, the middle coxæ are near together, the prosternum is not lobed anteriorly, and the antennæ are eleven-jointed. *A. pellio* is about 0.2 of an inch long, and dark brown with a white dot near the middle of each elytron. The abdomen of its larva ends in a pencil of long hairs. *A. negatoma*, and possibly at times other species of the genus, are the cause of a kind of felting of pillows and bed-ticks that is often a puzzle for housewives. These insects, having gained access to the inside of a bed-tick, breed in it, and bite off pieces of the feathers. These pieces, on account of the rolling and tumbling to which they are subjected in the bed, are driven, basal end first, into the ticking, where they are retained by the barbed nature of their tip, all of the branchlets pointing backwards. What is curious about this felting, which resembles mole-skin, is its remarkable evenness and beauty. A piece, from which I saw a sample several years ago, was made up into a lady's cloak, and suggested the possibility of producing this kind of dress-goods by using flock-cutters and fulling-mills to replace the slow processes by which this piece was made.

Anthrenus has been long well known to most collectors of plants and animals, and has lately introduced itself in America to the unwilling recognition of housewives. Two species, *A. varius* and *A. muscorum*, neither of them much larger than a good-

sized pin-head, are the best-known museum-pests. They are gray spotted with light brown. The beetles gain access to collections, and deposit their eggs upon insects, stuffed animals, and other dried animal matter. The larva when hatched bores into the specimens, oftentimes completely riddling or ruining them, and finally pupates within them. Their presence in collections of insects is betrayed by the débris which falls from



FIG. 440. — *Anthrenus muscorum*, larva and pupa.

the specimens attacked. To keep museum-pests from collections, resort is made to camphor, carbolic acid, naphthalin, and many other substances, which are kept

in the boxes with the specimens. These generally prevent the females from entering the boxes for the purpose of oviposition, but are not always to be relied upon as remedies when museum-pests are introduced. My own collection of insects is kept free from museum-pests by observing the following precautions. The collection is kept in closely shutting boxes, in a room which is not carpeted and which is solely devoted to the collection. No new insects are introduced into this room until they have been subjected to a disinfecting-box. This disinfecting-box is made of tin and is sixteen inches square and twelve inches deep. The perpendicular edges of its tin cover dip into a deep water-channel which surrounds the top of the box, a mode of water-sealing employed in gas-works purifiers which suggested the plan of this box. Whole boxes of specimens, when suspected or found to be infested with museum-pests, are put into this box, a little benzine poured into the bottom of the disinfecting-box, and the whole covered and left for a day or two.

Anthrenus scrophularia, probably lately introduced into America from Europe, has received the name of carpet-beetle and buffalo-bug in the eastern United States, on account of its habit, both as larva and imago, of destroying carpets. This beetle is somewhat larger than the last-mentioned species, measuring about 0.08 of an inch in length. Its colors are black, brick-red, and white, which are easily seen, with a lens of moderate power, to be scales arranged in mosaic-like patterns over a brownish-black surface. This insect, like the

other species of *Anthrenus*, feeds, out-of-doors, upon the pollen of plants, and often swarms upon flowers of different kinds of *Spiraea*, and upon those of the shad bush (*Amelanchier canadensis*). In-doors it attacks not only carpets and all kinds of woollen goods, but also collections of objects of natural history, plants, furs, hair, raw-hides, and like materials. Its larva, which, as usual with insects, does more damage than the perfect insect, is oval, about 0.25 of an inch long, and covered with long, brown hairs. In some parts of this country these insects have already become so abundant that carpets are a costly luxury, requiring constant care, and replacement every few years. A few people have adopted what seems at present the only practical remedy, the use of oiled floors covered with rugs, which latter, because they can be often removed and shaken, are not very subject to destruction by carpet-beetles and moths. The waxed hard-wood floors, often of pretty patterns, which are admired by American travellers in Europe, are the results of the solution of the problem of how to get rid of carpet-destroying insects by our artistic transatlantic brethren. To keep carpet-beetles out of clothing requires frequent examination and shaking of the goods. I have found that clothing can be freed from insects by a few days treatment in the disinfecting-box, in the same way as described for removing museum-pests from specimens. After such treatment, clothing can be safely packed away in closely shutting tin boxes in dry places.

Trogoderma differs from *Anthrenus* in having the mandibles and labrum not covered by the prosternum. *T. tarsale* is a common museum-pest in parts of the United States.

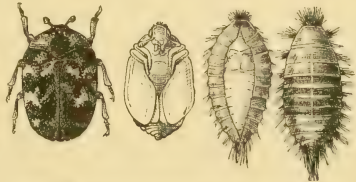


FIG. 441. *Anthrenus scrophulariae*, carpet-beetle, pupa and larva.

The **CRYPTOPHAGIDÆ** are beetles of small size, and usually of short, convex form. On account of their minuteness, these beetles attract little popular attention. Some of the species feed on fungi, some live in ants' nests, and others eat plants. The larvae of *Cryptophagus cellaris*, a European species, live in the cells of wild bees (*Anthophora retusa*) upon the excrement of the young bee-larvæ. *C. quercinus*, also a European species, lives in the nests of ants in oak trees. Professor A. S. Packard writes that he has found the larvæ of *Anthrophagus ochraceus* in the nests of humble-bees (*Bombus*) during July and August. It is likely that the species of *Anthrophagus*, which are frequenters of flowers, are carried into bees' nests by the bees themselves, since Perris has observed a *Bombus montanus*, to the antenna of which an *A. nigricornis* firmly clung. The genus *Atomaria* is made up of extremely small beetles, as its name indicates; these are oval, convex, and pubescent. Several species of *Atomaria* are myrmecophilous, others are destructive to plants. *A. linearis* has been known to ruin young beet-plants.

The family **CUCULIDÆ** includes a small number of Coleoptera which are remarkable for their excessively flattened, usually elongate form. Their abdomen has five free ventral segments which are equal in length; the antennæ are eleven-jointed and often enlarged apically; the prothorax is usually narrower than the elytra. The larvæ are elongated and depressed; some have five ocelli upon each side of the head, others none. The feet have each a simple claw. The tip of the abdomen is armed with a pair of curved horns. Both larvæ and beetles are found beneath the bark of decaying trees; some of them (*Prostomis*) live in society with ants; the larva of one species, at least, is carnivorous.

The species of *Brontes* have striate elytra, the sides of the prothorax serrate, and its anterior angles prolonged, the antennæ with the first joint elongated, the anterior coxal cavities open behind, and the maxillæ exposed. *B. dubius* is about 0.25 of an inch long, dark brown in color, and is not rare under bark of dead chestnut trees in the northeastern United States. In Europe *B. planatus* is found under bark of dead oaks.



FIG. 442. — *Cucujus clavipes*.

In the genus *Cucujus* the hind-tarsi are only four-jointed in the males; the prosternum is narrow, and the hind-angles of the head are prominent. *C. clavipes* is scarlet above, with black antennæ and eyes; its upper surface is finely punctate. I have found this species under decaying butternut bark, where its larva probably lives.

Catogenus differs from *Cucujus* in having its maxillæ covered by corneous plates, which are broad and rounded in front; the first tarsal joint is short. *C. rufus*, which varies from 0.25 to 0.50 of an inch long, is deep brown, and is found in the eastern United States. In parts of Connecticut it is common beneath the loose bark of the trunks of hickory trees, and I have reared its larva, which fed upon a pupa of *Elaphidion parallelum*, a borer in hickory.

In *Syleannus* the anterior coxal cavities are closed behind, the tarsi without lobes beneath, the outer three joints of the antennæ are enlarged. *S. surinamensis* breeds in grain, and, like most grain insects, has become widely distributed over the globe. It is dark brown, marked with yellowish pubescence, and is only about 0.1 of an inch long.

The family **COLYDIDÆ** comprises quite a number of very small, elongate, mostly cylindrical beetles, of little popular interest on account of their small size. Some of them live in fungi in the ground, or under bark of trees; a few are myrmecophilous,

and, according to Moullet, the larva of a species of *Bothrideres*, found in Guadalupe, is an internal parasite of larvæ of *Lagochirus araneiformis*, a cerambycid beetle.

The usually flattened species of *NITIDULIDÆ* have antennæ of eleven joints; these antennæ are inserted under the front, and have an apical club of three (rarely two) joints; the tarsi are variable, but more or less dilated, and their first joint is not short; the anterior coxæ are transverse and not prominent, the posterior ones flat and not sulcate; the labial palpi are approximate at the base; the ventral segments are free, and the legs short. These beetles and their larvæ feed in decomposing animal or vegetable matter, in fungi and higher plants of soft texture, under bark of decaying trees, on pollen, and an Australian species, *Brachyepelus auritus*, eats the wax in nests of bees of the genus *Trigona*.

The species of *Ips* have the antennal club made up of three joints, the labrum connate with the epistoma, the anterior coxæ open, and the thorax not margined at the base. *I. fasciatus*, common throughout the United States, is shining black, with a band or spot of yellow across the base, and another just behind the middle of each elytron. It eats decomposing animal and vegetable matter, being especially common in autumn upon decaying pumpkins or cabbage-stalks which have been left in the fields. *Ips ferruginea*, of Europe is said to feed upon larvæ of *Hylesinus piniperda*. Species of *Ips*, and of other Nitidulidæ, also frequent stumps of freshly-cut birch and maple trees early in the spring, in order to eat the sap which oozes from them.



FIG. 443. — *Ips fasciatus*.



FIG. 444. — *Nitidula bipustulata*.

In *Omosita* the labrum is entire and free, the head horizontal, the prothorax not margined at the base, the tarsi moderately dilated, and the front not lobed over the antennæ. *O. colon* is found in the eastern United States and in Europe. It is about 0.12 of an inch long, much flattened, is deep brown, spotted upon the elytra with light brown; it frequents decomposing animal and vegetable matter. *O. discoidea*, a slightly more elongate form than *O. colon*, inhabits Europe and the western United States.

Of similar form to *Omosita*, but differing from it structurally in having strongly dilated tarsi and feebly emarginate labrum, are the species of *Nitidula*, of which *N. bipustulata* is found in Europe and the eastern United States. This species is about 0.2 of an inch long, and dark brown with a light-brown spot near the middle of each elytron. Its

habits are similar to those of *Omosita*.

Dr. G. H. Horn writes of *Carpophilus*, "Labrum bilobed. Antennæ eleven-jointed, terminated by a flattened-oval, three-jointed club, grooves moderately deep, convergent. Legs moderately robust, tibiæ slightly broader at tip, spurs moderate. Tarsi dilated, claws simple. Two, sometimes three, dorsal segments visible beyond the elytra; abdomen beneath with segments 2-3 short, 1-4-5 longer." *C. hemipterus*, a species about 0.15 of an inch long, distributed over most parts of the globe. It is dark brown, with pale spots upon the elytra.



FIG. 445. — *Carpophilus hemipterus*.

In *Conotelus* the abdominal segments are greatly prolonged, so that the abdomen projects far beyond the elytra, as it does in the Staphylinidæ. *C. obscurus*, a black

species with brownish legs and antennæ, and about 0.2 of an inch long, is often very abundant in flowers of the wild morning-glory (*Calyptegia sepium*) in the northeastern United States.

Separated from the species of the preceding family by their slender tarsi, of which the first joint is short, are the TROGOSITIDÆ. Of this family there are two groups readily distinguished by their form. The species of the first group are elongate insects with the prothorax narrowed behind. *Trogosita mauritanica* is a cosmopolitan species of this group. It is deep brown, flattened, and about 0.4 of an inch long. The species of *Trogosita* are often found under decaying bark, but certain of them have proved to be very injurious to grain, and to other articles of commerce. *Thymalus*



FIG. 446. — *Trogosita mauritanica*.

fulgidus is a common representative of the second group of the Trogositidæ, which contains oval species. This is a nearly round, somewhat flattened species, about 0.2 of an inch long, which abounds on *Polyporus betulinus*, a large, white fungus that is parasitic on trunks of dead birch trees. The beetle is a slightly shining bronze color, and is both punctate and pubescent. Its larva is 0.3 to 0.4 of an inch long, somewhat flattened, and has the anal extremity armed with two parallel, acute, corneous processes, along the sides of which are a few sharp, short branches. The larva, which is of a hyaline white with a yellowish head, has five ocelli on each side of the head. The larvæ generally destroy the tough tissue of the above-mentioned fungus during the early spring, in the eastern United States, and pupate in the remnants of their food-plant, the beetles emerging during the summer.

A considerable number of small beetles that are, for the most part, round, hard, and seed-like in appearance, and generally live upon decaying animal or vegetable matter, are united in the family HISTERIDÆ. They differ systematically from the Ni-

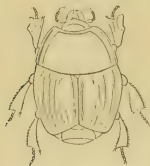


FIG. 447. — *Hister arcuatus*.



FIG. 448. — *Hister bimaculatus*.



FIG. 449. — *Onthophilus alternatus*.

tidulidæ in having geniculate antennæ. Most of the Histeridæ are black, a few have red spots, and a small number are metallic in coloration; all their tibiæ are usually dilated; the elytra are truncate behind, leaving two abdominal segments exposed; the upper surface is striate, the position and nature of the striæ being generally of value as specific characters. The larvæ of the Histeridæ are elongated, with corneous head and prothorax, and have no ocelli. Some species of this family inhabit ants' nests, a few live under bark. *Hister helvus* is known to eat larvæ of *Agelastica alni*, and *H. pustulosus* drags the larvæ of *Agrotis*, a noctuid moth, from their holes and devours them, in company with others of its species that hasten to the repast.

In the species of *Saprinus* the head is bent downward and retracted; the prothorax is truncate anteriorly, and has cavities at its side for the reception of the antennæ, which are inserted beneath the front. There are nearly sixty North American species

of this genus; most of them are found about carcasses; the species are difficult to distinguish.

In *Hister*, another large genus, well represented in North America, the prosternum is lobed anteriorly, the antennal club is broadly oval and distinctly annulated, the labrum trapezoidal, and the cavities for the reception of the antennæ are anteriorly situated, and open in front. *H. arcuatus* is one of the largest North American species, being about 0.35 of an inch long, and marked with a curved red stripe upon each elytrum. *H. bimaculatus* is found both in Europe and North America. Closely related to *Hister*, but having a truncate antennal club, and a transverse labrum, is *Tribolus*. *T. scaphidiformis*



FIG. 450. — *Saproscius maculatus*.



FIG. 451. — *Hololepta fossularis*.

is found in Algiers and Portugal. In *Onthophilus* the antennal cavities, which are beneath the angle of the prothorax, are open below and closed in front, and the prosternum is scarcely lobed in front. *O. alternatus*, a small species, not over 0.1 of an inch long, is from the eastern United States.

The species of *Hololepta* are quite different, in general appearance, from all the other Histeridæ. They are very much flattened, the head and mandibles are prominent. *H. fossularis* is about 0.4 of an inch long, shining black, and is found in the eastern United States beneath the bark of decaying trees.

The SCAPHIDÆ contain a small number of very shiny beetles of similar form and coloration to the Histeridæ, but easily distinguished from the latter by their clavate antennæ, which are not geniculate, and by other structural characters. The larvæ are said to have long antennæ.

The family of PHALACRIDÆ is small, and consists of only four genera of little convex shining beetles, that live upon flowers or under bark. *Phalacrus*, *Olibrus*, and *Litochrus* are represented in the North American fauna. *Tolyphus granulatus*, which is here figured, belongs to the only other genus, and is from southern France and northern Africa.



FIG. 452. — *Tolyphus granulatus*.

The TRICHOPTERYGIDÆ are the smallest known beetles. The antennæ are verticillate with long hair, and the wings are fringed with hair. A few are apterous. The larvæ are active and carnivorous, those of some species feeding on Poduridæ. Pupation lasts but a few days. Quite a number of the Trichopterygidæ are myrmecophilous, others live under bark. *Trichopteryx atomaria* is found both in Europe and in America.



FIG. 453. — *Trichopteryx atomaria*.

The typical carrion-beetles belong to the family SILPHIDÆ. These beetles are often of considerable size, and have clavate antennæ. The characters which Drs. Le Conte and Horn give to separate the beetles of this family from others having clavate antennæ are as follows: dorsal segments of the abdomen partly membranous, ventral segments free, mentum moderate or small, palpi approximate at their bases; anterior coxæ large, conical, and prominent; posterior coxæ more or less conical and prominent; eyes finely granulated, sometimes

absent. While most of these beetles live upon carrion, attacking by preference decaying animal matter, a few have mixed habits and attack decomposing and even living



FIG. 454. — *Necrophorus subterraneus*.

vegetation, while some are known, when pressed by hunger, to eat living insects, not sparing their own species. *Leptinus testaceus* has been found in Normandy by Mr. A. Fauvel in the nests of mice, where it is supposed to feed on fungi. Mr. M. Girard has described an eyeless species, *Scotocryptus meliponæ*, from the nests of bees (*Melipona scutellaris*) in Brazil. Other eyeless forms (species of *Leptoderus*), together with others (*Adelops*) that have very small eyes, inhabit caves. In *Arimimelus lebioides*, from Japan, there is an ocellus behind each compound eye. Some species of *Calops* inhabit ants' nests. Species of *Necrophorus* stridulate. Many kinds of Silphidæ emit nauseous fluids, and their odor remains disagreeable

after years of drying in the collection. The species of this family, even in the larval state, are very sensitive to odors, and are guided by their olfactory organs to their food.

The larvæ of Silphidæ have six legs, four-jointed antennæ, strong bidentate mandibles, three-jointed maxillary and two-jointed labial palpi, and generally a two-jointed appendage each side of the anus. The ocelli vary in number, there being none in *Adelops* and *Anisotoma*, two pairs in *Agathidium*, and six pairs in *Silpha* and most other genera. The larvæ generally inhabit the same places and devour the same food as do the imagos.

Among some of the smaller species, which have the posterior coxæ simple and the anterior coxal cavities closed behind, those of *Anistoma* and *Agathidium* live in fungi.

Adelops, a word which signifies inconspicuous-eyed, is the name of a genus of beetles which have been erroneously said to be eyeless. The species have slender antennæ, which are longer than the head and thorax, and a prominently carinate mesosternum. *A. hirtus* was first described from a specimen taken under a stone in Mammoth Cave, Kentucky, and has since been found in other caves of the same region. It is oval in form, grayish brown, and about 0.1 of an inch long. Its larva and pupa have been described by Mr. H. G. Hubbard.

The genera *Silpha* and *Necrophorus* include the largest and best-known species of this family. In *Silpha* the form is flat, oval, or nearly so; the antennæ are eleven-jointed, and gradually increase in size from the middle toward the apex, or are slender and scarcely clubbed. *S. americana* (sometimes called *S. peltata*) is about 0.7 of an inch long. Its prothorax is yellow with a dull black median spot, its elytra are brownish black and rough. *S. atrata*, which is said to have been introduced into America from Europe, is about 0.4 of an inch long, black, densely punctured, and with elevated elytral ridges, between which the punctures are irregularly arranged. Its antennæ are nearly filiform. Another species, found both in Europe and North America, is *S. lapponica*, which is about the same size as *S. atrata*, but has a gray pubescent prothorax and dull-black elytra, the latter roughened by ridges with single rows of irregular protuberances between them. In New England *S. inæqualis* and *S. noveboracensis* are common species. Both are a little larger than *S. atrata*, and have the prothorax and elytra longitudinally wavy; the former is entirely black, the



FIG. 455. — *Silpha americana*.

latter has the sides of the prothorax light red. As was noticed by Frisch, in 1740, in describing the larva of the European *S. obscura*, these larvæ are sometimes phytophagous, and in the last few years numerous notices have been published of injury to crops, especially to young sugar-beets, by larvæ and inagots of the last-mentioned species and of *S. opaca* and *S. reticulata*. Late experiments have shown that some of these species prefer vegetable to animal food. Sexual activity is great in *Silpha*; and Dr. C. F. Gissler has written of *S. ramosa*, a species from the western United States: "They copulate every few hours, the male constantly pursues and annoys the female, often snapping at the latter and biting into tips of elytra, for which reason these (in collections) are so often found lacerated. The female is often found burrowed into the soil to escape the caressings of the male, and also for oviposition, which takes place there." The oval eggs of this species, as Dr. Gissler has observed, are very large in comparison with the insects' size, measuring about 0.1 of an inch in length, while the beetle is only from 0.6 to 0.7 of an inch long. The larvæ of *Silpha* are dark colored and flat, having the characters already given for larvæ of this family.



FIG. 456. — *Silpha atrata*.

The species of *Necrophorus* have ten-jointed antennæ with a four-jointed round club, and are of an elongated form, with red-spotted elytra, which are truncated at their tips. On account of their habit of burying small dead vertebrate animals, in

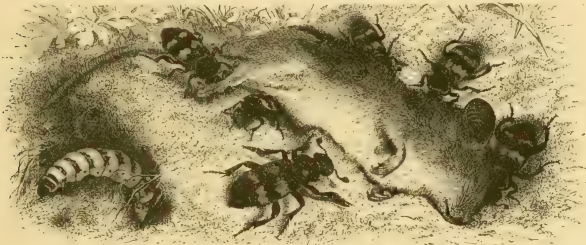


FIG. 457. — *Necrophorus vespillo*, grave-diggers at work.

which they lay their eggs, these beetles are often called sextons or grave-diggers. This habit makes these beetles useful scavengers. The largest North American species of this genus is *N. americanus*. It is 1.25 to 1.50 inches long, the top of the head is red, the pronotum is of the same color margined laterally and behind with black, and there are two red spots on the outer side of each elytron, one just anterior to its middle and one near its tip. *N. tomentosus* is a common species in the northeastern United States, and is about 0.75 of an inch long. Its prothorax is clothed with dense yellow pubescences, and the red spots extend nearly across the elytra. Somewhat resembling the last-mentioned species is *N. respillio* from Europe. *N. germanicus*, a nearly black European species a little over an inch long, captures and devours *Geotrupes stercorarius*.

The SCYDMENIDÆ differs from the Silphidæ in having coarsely granulated eyes.

Dr. Le Conte says of the beetles of this family: "These are small, shining, usually ovate, sometimes slender insects of a brown color, more or less clothed with erect hairs. They are found variously near water, under stones, in ants' nests, and under bark, and are frequently seen flying in the twilight."

A small portion of the Coleoptera with claviform antennæ have the dorsal segments of the abdomen entirely corneous and the elytra very short, not covering the abdomen. Of this portion the PSELAPHIDÆ have the abdomen rigid and the ventral segments five or six in number. The antennæ have from one to eleven joints, the labial palpi are very short, the maxillary palpi are usually long and four-jointed, eyes are sometimes absent, claws simple and frequently single, wings often wanting. The species of this family are all very small and many are myrmecophilous, living on friendly terms with ants. As cause for this friendly relationship, it is said that certain species of Pselaphidæ secrete, as do the Aphidæ, fluids which the ants eat. This kind of life has been so long participated in by these beetles that many species are blind, and are fed, carried about, and protected by the ants exactly as they care for their own larvæ; this is the case with *Claviger testaceus*, a European species which has connate elytra and is apterous. Certain species of this family live in caves, and one of them, *Macharites subterraneus*, is peculiar in having males with eyes and females without these organs. In *Articerus*, of which several species are found in Australia, the antennæ are one-jointed. In the North American genera, *Adranes* and *Fustiger*, the antennæ have but two joints, and in the former genus, eyes are wanting.

The STAPHYLINIDÆ, which, like the Pselaphidæ, have short elytra, differ from the latter family in having the abdomen flexible and consisting of eight ventral segments. While including many minute forms, this family also includes some species that are an inch or more in length. The antennæ are generally eleven-jointed, but are variable in form and insertion, the labial palpi are usually three-jointed, the maxillary palpi generally four-jointed. The short truncate elytra usually leave most of the abdomen exposed; and when these beetles are disturbed, many of them turn the tip of the abdomen over the body as if intending to sting. Some of them discharge odorous defensive fluids from the tip of the abdomen when they have assumed this threatening position. The wings, when present, can be closely packed away beneath the short elytra. In *Pachyeorinus dimorphus* from New Zealand, Mr. A. Tauvel has noticed that the females are dimorphic, the form that has normal eyes has longer elytra and wings, while the partly-blind form has very short elytra and no wings — a curious correlation of locomotion and sight. Some species of Staphylinidæ have, in addition to the compound eyes, a pair of ocelli.



FIG. 458. — Larvæ of *Ocyptus*.

The larvæ of Staphylinidæ resemble the imagos more than is usual with Coleopterous larvæ, chiefly on account of the larval-like appearance of the imagos themselves. The antennæ are always four-jointed, although apparently five-jointed in some genera. The mouth-parts are well developed, the maxillary palpi are of three or four joints, the ocelli vary according to genera from one to six on each side, the body is elongate and is usually armed at the anal end with a pair of appendages which are mostly two-jointed. These agile larvæ are of a firm texture, of a brownish black or yellowish color, and they pupate, for the most part, underground or beneath rubbish on the ground. In many forms the metamorphosis lasts but one year.

The larvæ of this family usually live in similar places to those frequented by the imago; and, while their habits and life history have been little studied in comparison with other families of equal size, there is great and interesting variety in their habits. Some of the species live under bark, others eat fungi, many live about decaying plants and the excrements of higher animals. Quite a number are found in the nests of ants, but the exact relations which they hold to the ants are not yet determined. Mr. E. A. Schwarz has found species of Staphylinidæ in Texas in the nests of white ants (*Termites*), which, as will be recollected, are not Hymenoptera, as are the true ants. *Quedius dilatatus* breeds in hornets' nests in Europe, and will also eat honey. *Microglotta nidicola* frequents the nests of bank-swallows in France, and Mr. P. S. Sprague discovered that *Allochatra anthomyia*, in the eastern United States, was parasitic in the cabbage-maggot (larva of *Anthomyia brassica*). Heeger found that *Gyrophana manca* oviposits on leaves of plants. The larvæ, when first hatched, eat the eggs of mites, and later devour the larval mites themselves, finally pupating in moist earth. In a termitophilous South American genus the abdomen is soft, very much enlarged, and thrown upwards and forwards so as to hide the thorax. The eggs of these curious insects develop into larvæ, while still in the abdomen of the female, a fact first discovered by the late Professor Schiödte of Copenhagen, who, on account of its viviparous habits, named the genus *Corotoca*.

The rather robust species of *Ocyporus* are found in fungi. The head is large, the eyes small, the long mandibles are not dentate, and the abdomen is strongly margined. *O. vittatus* is about 0.25 of an inch long, and black above with a light-brown longitudinal stripe covering nearly the whole of each elytron, and the margin of the abdomen is brown. It is common in the northeastern United States on species of *Agaricus*. The species of *Paderus* are combinations of red and deep metallic blue in coloration, and are found under chips and stones in moist places. In *P. riparius* the head, elytra, and tip of the abdomen are blue, the rest of the insect for the most part red. It is about 0.3 of an inch long, and inhabits both Europe and America. In similar moist localities, as those in which *Paderus* is found, live numerous species of *Stenus*, a genus of small Staphylinidæ, which have very prominent eyes, a broad head, narrow prothorax, and wide subquadrate elytra.

The largest species of this family are members of the tribe Staphylinini. The genus *Staphylinus* contains species often of considerable size. *S. maculosus*, common in the eastern part of North America, is from 0.7 to 1 inch long, is dull brown, densely punctate, and the tip of the pubescent abdomen is lighter brown. Of about the same size, and found in the same localities, is *Leistotrophus cinquedatus*. This species is brown, speckled with brownish-black spots, and the apical portion of its abdomen is clothed with golden pubescence. It differs generically from *Staphylinus* in having the fourth joint of the maxillary palpi shorter than the third. Differing from the last-mentioned genera, in having the thorax without punctures, are the genera *Creophilus* and *Thinopinus*. *C. villosus*, the only North American species, is widely distributed over the country. It is from 0.5 to 0.9 of an inch long, of a black ground color marked with gray pubescence, especially upon the margins of the abdomen and in a band across the elytra. *C. macillosus*, from Europe, is a very similar species to *C. villosus*. *Thinopinus pictus*, which lives below high-water mark on the shores of the Pacific Ocean from Alaska to southern California, is from 0.55 to 0.75 of an inch long, of a yellowish-brown color, spotted above with dark brown and black.

Numerous species of the genera *Bledius*, *Cryptobium*, *Lathrobium*, *Philonthus*, *Quedius*, *Aleochara*, and *Homalota* are found in the United States, but their specific and even their generic determination is often difficult. *Aleochara brachypterus*, which is figured, occurs both in Europe and in North America.



FIG. 459. — *Aleochara brachypterus*.

The family PLATYPSYLLIDÆ consists of a single species, *Platysylla castoris*, an ovate, elongate, much-flattened parasite of the beaver (*Castor fiber*). The beetle is only 0.16 of an inch long, and has neither eyes nor wings; the elytra are short, leaving five abdominal segments exposed. This insect was first described by Ritsema in 1869 as a new genus and species of Aphaniptera, but its coleopterous nature was pointed out in 1872 by Dr. J. L. Le Conte. Professor J. O. Westwood considers it to represent a distinct order of insects, the Achreioptera.



FIG. 460. — *Platysylla castoris*.

With the family HYDROPHILIDÆ begins a series of several families of Coleoptera which inhabit water, or, in a few cases, extremely moist places. Of these families only



FIG. 461. — *Hydrophilus piceus*, larva, male, female, and egg-nest.

the Hydrophilidæ have clavate antennæ. The antennæ have from six to nine joints, the outer joints forming a distinct club, the palpi are long, the middle and posterior legs are sometimes flattened and fitted for swimming. The imagos of this family are said to eat vegetable matter, either decomposed or living, and this is probably true of many species; but certain kinds of *Hydrophilus* prefer animal matter when they can obtain it. Robert writes that *H. piceus* feeds upon snails (*Limnæus*), and I found that this species ate greedily fresh meat or fish in preference to vegetable matter in an aquarium. Westwood asserts, however, that *H. fennicus* eats turnip leaves in the

fields during the night. The insects of this family respire under water from a supply of air which they carry about attached to the pubescence of the under surface of their bodies; and this air, which appears like a sheet of silver beneath the beetle when in the water, is often renewed by the insect coming to the surface.

The life history and habits of some of the Hydrophilidæ are interesting in the extreme because of the nest which the females construct and in which they deposit their eggs. This cocoon-like nest is produced by the hardening of a gelatinous secretion from accessory glands of the sexual organs of the females, and in it are deposited from twenty to over one hundred eggs, according to the species. The cocoon is fastened by some of these beetles to submerged vegetation, by others it is left to float on the surface of the water, and the females of still other species carry their cocoon about beneath them, fastened between the posterior coxæ and steadied by the hind legs, until the young larvæ have hatched. The larvæ are recognized, according to Professor J. C. Schödte, by their "claw-formed tarsi, which are sometimes wanting, the terminal pair of stigmata, the free projecting mouth-parts, the very short joint membrane of the maxillæ, the connate clypeus and absence of the labrum, the sharp, sickle-formed, imperforate mandibles, the absent or sharp ligula, the want of a neck on the extended head, and the very short, unarmed anal segment." The larvæ when first hatched often prey upon one another in the same cocoon; later they feed upon insects which fall into the water, and upon snails. In the case of the larvæ of *Hydrophilus piceus*, which eat common house-flies with avidity, the mode of feeding is curious. Seizing the fly in its jaws, the swiftly swimming larva seeks some place where it can eat it in quiet and security. Having found a suitable place, it rests upon a piece of grass or leaf and projects the head above the surface of the water, holding it perpendicularly. In this position it chews the fly into a pulp, using the antennæ as mouth-parts during the process, and sucking the juices of the fly down its throat, which, during the mastication, acts as a tunnel to catch the juices crushed from the fly. The head is apparently held above the surface of the water in order that the juices of the prey shall not be diluted by the water. After the juices have been sucked from the fly its chitinous parts are rejected, at least by young *Hydrophilus* larvæ, in the same way as like innutritious parts of its prey are rejected by scorpions after they have drawn the juices from it. Pupation takes place in the ground.

Among the small species of Hydrophilidæ are a number of very convex form, terrestrial habits, and having the middle and hind tarsi with the first joint elongated. Of these small forms species of *Sphæridium* have a narrow mesosternum and elongated scutellum. *S. scarabæoides* is black, with yellow legs, a yellow spot on the tip of each elytron, and just in front of this yellow spot a larger blood-red one. It lives in cow-dung in Europe, and a single specimen, perhaps accidental in occurrence, has been reported from Canada. The larvæ of *Sphæridium* and of *Corygon*, related genera, live in moist earth and in dung, and prey upon dipterous larvæ.



FIG. 462. — *Sphæridium scarabæoides*.

Hydrobius and *Phyllidæus* include closely related aquatic species which have the middle and hind tarsi not compressed and with the first joint short, and in which the prothorax at the base is as wide as are the elytra. The last of the five exposed ventral segments is entire, and the antennæ are nine-jointed. In *Hydrobius* the last joint of the maxillary palpi is longer than the third joint. In *Phyllidæus* the last joint is shorter than the third. *H. globosus* and *P. rotundatus* are similar appearing, smooth,

shining black species, found in the northeastern United States. The form is nearly hemispherical, the length from 0.3 to 0.4 of an inch.

The genus *Hydrophilus* contains the largest species of this family. They differ from *Hydrobius* and genera associated with it in having compressed tarsi, and in having the metasternum prolonged posteriorly into a long spine.

H. triangularis, a common North American species, is 1.5 inches long, and shining black in color. The egg-case of this species has been carefully described by Dr. C. V. Riley. It consists of three parts, a floater surmounted by a horn-shaped process, an egg-case proper, attached to the basal end of the floater, and an outer bag or covering. The larvæ remain a day or two in the outer bag after they hatch; and Dr. Riley concludes "that the curious contrivance in *Hydrophilus* is intended not only to secure an ample supply of air to the eggs and to protect them, but also to protect the newly hatched young from their numerous enemies until their jaws have strengthened and they are better able to begin the struggle for existence." The eggs are white, cylindroid, and about 0.15 of an inch long and .04 of an inch in diameter. In Europe the corresponding large species of this genus is *H. piceus*, both sexes of which are figured above, with nest and larva. The sexes of these insects are easily distinguished, because the male has the anterior tarsi much enlarged, to form an organ, common among water beetles, by which



FIG. 463. — *Hydrophilus triangularis*.

he clings firmly to the female during copulation. Notwithstanding the reputed phytophagous habits of the imago of *H. piceus*, this beetle sometimes captures and eats *Triton punctatus*, when confined in an aquarium.

Nearly related to *Hydrophilus*, but having a short metasternal spine, is *Hydrocharis*. *H. obtusatus*, an oval black species, about 0.7 of an inch long, is common in the eastern United States. Several smaller species are united in the genus *Tropisternus*, of which *T. glaber* is an abundant species in New England.

The remaining families of beetles are often termed Adephaga, and are characterized by Drs. Le Conte and Horn as having the first three ventral segments connate; the first divided by the hind coxal cavities, so that the sides are separated from the very small medial part. The Adephaga are pre-eminently predaceous Coleoptera, although, as will be seen later, a few partake of vegetable food.



FIG. 464. — *Tropisternus glaber*.



FIG. 465. — *Dineutus vittatus*.

The GYRINIDÆ includes a small number of Coleoptera which swim rapidly about in groups upon the water, unless disturbed, when they dive beneath the surface. They are noticeable for their having a pair of eyes upon the upper surface of the head, with which to look out into the air, and a pair upon the under side for sight under water. Their flattened oval form and bluish-black color, together with their four eyes, serve to distinguish them from all other Coleoptera. When seized they emit an odorous milky fluid. In *Gyrinus* the scutellum is distinct, while in *Dineutus* it is wanting. The only other North American genus is *Gyretes*, of which a species is found in Illinois, Arizona, and Texas, and which differs from *Dineutus* in having the last ventral segment of the abdomen elongated and conical. *Dineutus*

vittatus is the largest species from the United States, where it is common in the Atlantic region. It is about 0.55 of an inch long, and the elytra have rounded tips.

The larvae of Gyrinidae respire by means of ciliate gills and a closed tracheal system. These gills are situated one on each side of every abdominal segment, and an additional pair upon each side of the anus, — in all, ten pairs of gills. These ciliate branchiae serve as swimming organs, enabling the larvae to swim rapidly. Notwithstanding their active aquatic life these larvae are subject to parasitism by three or four species of Hymenoptera.

The flattened water-beetles belonging to the family DYTISCIDÆ live in the water as do the Hydrophilidae, rather than upon it like the Gyrinidae, from all of which insects



FIG. 465. — *Hydrotus griseostriatus*.

they are readily distinguished by their filiform eleven-jointed antennæ. The Dytiscidae have but two eyes, their metasternum has no antecoxal piece, and is prolonged in a triangular process posteriorly, their abdomen has six segments. The legs of these beetles, especially the posterior pair, are oar-shaped and clothed with long hair, being consequently well fitted for natation; but these insects are not confined to swimming as a mode of locomotion, for they are provided with serviceable wings, and during the night fly from pond to pond. These beetles are apparently guided to water by sight, for they often fly against green-houses, the glass of which they mistake for the surface of water. Many Dytiscidae emit between the

head and prothorax, a milky secretion, and between the mesothorax and metathorax a yellowish fluid; the function of both these odorless fluids is not determined with certainty. At each side of the anal end of the intestine are two glands which furnish a strong odorous, acid fluid, said to contain butyric acid; these anal glands, which are not rare in adepagous Coleoptera, are defensive in function.

Many species of Dytiscidae stridulate; that is, produce more or less musical sounds, both under water and in air. Species of *Aeilus*, *Dytiscus*, and *Colymbetes* produce sound by rubbing the abdominal segments upon the elytra; the males of *Cybister*, by action of the posterior femora upon a corrugated spot behind the hind coxæ; and *Pelobius*, a genus placed by some authors in another family, by friction of the stout margin of the wings against the under side of the elytra. The anterior and often the middle tarsi of males, in certain genera of this family, have a part of their joints widened, and provided with pedunculate suckers beneath. These suckers enable the males to adhere firmly to the females during copulation. In the males of *Dytiscus* and of some allied genera the three basal joints of the anterior tarsi, which are the ones most strikingly modified, are so widely expanded as to form unitedly a saucer-shaped disc, which bears on its under surface two large and numerous small chitinous suckers mounted on stems. These somewhat toadstool-formed suckers are altered tarsal hairs. The females of some species of Dytiscidae exhibit an interesting dimorphism in that some of the individuals have the elytra striate, while others of the same species have them smooth. Different species of Dytiscus have been known to copulate with each other, and Kraatz has published a notice of a bastard between two species of this genus. Dytiscidae are rarely found in salt water, and their occurrence there is apparently accidental and temporary. Species



FIG. 467. — *Dytiscus cinctus*.

occur, however, in hot springs, and Hooker writes of a Himalayan species that was found abundantly in springs which had a temperature of 112° F. Insects of this family respire, when under water, a supply of air which they carry beneath their elytra, and which they renew, from time to time, by coming to the surface, and resting with the head hanging and the tip of the abdomen just at the surface of the water. Some of them remain submerged an hour and a half, before renewing their supply of air. The larger species of Dytiscidæ often attack small fishes.

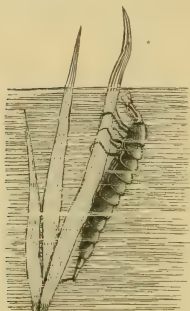


FIG. 468. — Larva of *Dytiscus*.

The larvæ of the Dytiscidæ, which are aquatic in habits, and have free mouth-parts, five-jointed thoracic legs, four-jointed antennæ, and six pairs of ocelli, are especially noticeable because their mandibles are hollow, and are consequently adapted both for seizing their prey and for sucking out its juices. The mouth cavity between the mandibles is not, as is often asserted, entirely closed. The larvæ respire by means of two stigmata at the posterior end of the abdomen.

Cybister has the suckers on the under side of the tarsal disc alike, and arranged in four rows. *C. fimbriolatus*, from the eastern United States, is greenish black, margined with yellow, and is about 1.25 inches long. In *Dytiscus* the suckers of the tarsal disc are of different sizes, and the posterior stigmata are larger than in *Cybister*; the species are all large. *D. fusciventris*, a species about 1.1 inches long, is common in New England, and *D. verticalis*, about 1.3 inches long, is not very rare in the same region. Both are black, with yellow lateral margins of the prothorax and elytra. In Europe *D. marginalis*, a species about the size of *D. fusciventris*, is the common one, and its larvæ attack young frogs, tritons, and fishes.

The species of *Acilius* are of medium size, and have the posterior tarsi ciliate, the claws of the same tarsi equal or nearly so. Many of the species have a yellowish band across the posterior half of the elytra, and transverse yellowish lines on the prothorax.



FIG. 469. — *Matus bicarinatus*.



FIG. 470. — *Rhantus notatus*.



FIG. 471. — *Hybini ater*.



FIG. 472. — *Coptotomus interogatus*.

The tarsal discs of the males are round. *A. fraternus* is very common in New England. Its length is about 0.6 of an inch, and the black portions of its elytra have a yellowish tinge, due to the black consisting of very dense punctures upon a yellow surface. *A. sulcatus* is the common representative of this genus in Europe.

In *Rhantus* the discs of the anterior tarsi of the males are oblong, and the elytra smooth. *Rhantus notatus*, a species about 0.4 of an inch long, is found in Europe

and North America. The species of *Agabus*, *Matus*, and *Hybius* are all somewhat similar in appearance to *Rhantus*, and most of the species are about the same size. *Coptotomus interrogatus* is very common in the eastern United States. It is about 0.35 of an inch long, the elytra are somewhat irregularly striped longitudinally with yellow, and the prothorax is banded transversely with the same color.

In *Hydroporus*, a genus which contains over seventy-five described North American species, the prosternum is deflexed between the front coxæ, the anterior and middle tarsi are apparently four-jointed, the scutellum is not visible, and the metasternum attains the mesosternum. The species are all of comparatively small size.



FIG. 44. — *Hydrophilus fasciatus*.

The family HALIPIDÆ, often united with the Dytiscidæ, includes a small number of minute, sub-aquatic Coleoptera, which are oval and very convex, and which swim poorly. They are yellow, spotted with black. Their metasternum has an ante-coxal piece separated by a distinct suture, and their antennæ are ten-jointed.



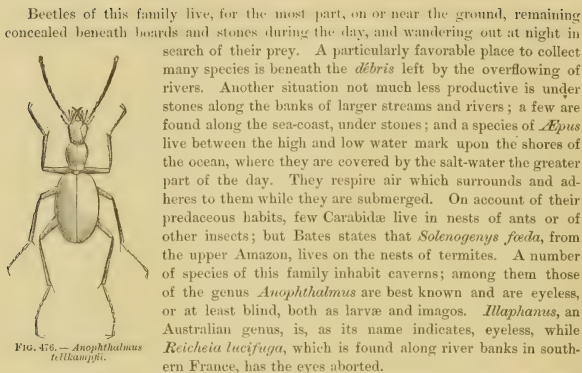
FIG. 45. — *Hydrophilus rotundatus*.

The CARABIDÆ number probably over ten thousand described species, varying in size from very minute forms up to beetles from two to three inches in length. Drs. Le Conte and Horn give the following characters by which species of this family can be readily distinguished from other adephagous coleoptera: Metasternum with an ante-coxal piece, separated by a well-marked suture, reaching from one side to the other, and extending in a triangular process between the hind coxæ; eleven-jointed antennæ arising at the side of the head, between the base of the mandibles and the eyes; hind coxæ mobile and simple; and habits terrestrial. These beetles have slender legs, and run rapidly; the wings are often poorly developed. On account of their rapid running habits, the Germans term these Coleoptera "Laufkafer." Sonorific organs are not common in insects of this family, but species of *Blethisa* and of *Elaphrus* stridulate. Luminous organs have been reported in the case of *Physodera noctiluca* from Java.

A large number of Carabidæ have anal glands, which have been mistaken by some writers for urinary organs, but which are defensive in function. The muscular bladder-like receptacles of these glands are two in number, one on each side of the terminal portion of the intestine, and each opens just above the rectal opening. Into these receptacles, which serve to store the defensive fluid until needed, open the ducts of the glands which prepare the secretion. In most cases the secretion is an odorous acid liquid, which can be spurted out quite a distance, and Pelouze has shown that, in certain species of *Carabus*, this secretion contained butyric acid, the same acid that imparts its indescribable odor to rancid butter. In *Brachinus* and a few other genera the secretion of the anal glands is either partly gaseous on emission, or becomes a permanent gas immediately afterwards, as can be readily proved by compelling one of the insects to discharge its secretion under water beneath an inverted test-tube filled with the same liquid. In this way I have collected, in a few moments, from *Aptinus displosor*, a Pyrenean species related to *Brachinus*, an amount of gas equal to several times the space occupied by the beetle itself. The discharge of the anal glands of *Brachinus*, often rapidly repeated when the beetle is held between the fingers, is accompanied by a smoke-like vapor and a popping sound, whence insects of that genus are popularly termed bombardier-beetles.



FIG. 47. — *Brachinus fannius*, bombardier beetle.



The larvæ of Carabidæ are elongated, often partly corneous. They have four-jointed antennæ, and somewhat long five-jointed legs. The mandibles are falciform and prominent, the maxillary palpi are four-jointed, the labial palpi two-jointed, and the ocelli are generally from four to six on each side. In the larvæ of *Scarites* and *Anophthalmus*, and of a few other genera, ocelli are absent. It is usually stated that carabid larvæ, like those of the Cicindelidæ, Dytiscidæ, and Gyrinidæ, and unlike those of most other families, have two claws on each foot; but this character is not without exception in the carabid larvæ, for the larvæ of *Æpus*, a genus already mentioned, and of *Cilleum*, are stated to have but one claw on each foot. Chapuis and Candèze write: "The color of these larvæ varies from a light brown to a deep black, and, exceptionally, to yellowish white. They are very active, and wander about upon the ground. The greater part of them live upon prey which they get possession of in various ways. Thus insects, caterpillars, and molluses form their ordinary food. They do not tear this prey to pieces, but limit themselves to extracting its juices, a circumstance that explains the smallness of their buccal aperture. Some live on vegetable substances. This fact, proved for *Zabrus gibbus*, probably will be the same with the greater part of the larvæ of Harpalini and of *Amara*." This prediction as to the phytophagous habits of Carabidæ has since proved true, and quite a large number of these insects are known to feed upon pollen and other parts of plants, while the *Zabrus* mentioned above has proved at times destructive to young turnip plants and to other crops. In parts of California *Platynus maculicollis* has become so abundant as to be a nuisance, swarming in every corner, and entering food and clothing in masses. The popular name given this beetle is "overflow-bug." With the exception of *Zabrus gibbus* and *Platynus maculicollis*, the insects of this family may be regarded as generally beneficial, for the phytophagous species mostly devour the pollen and seed of weeds, while the great majority of Carabidæ attack the larvæ of noxious insects.

Among curious food habits of Carabidæ it may be mentioned that D'Aumont observed that *Brachinus crepitans*, in company with carrion beetles, helped devour a

dead snake. According to a statement lately made by J. Frivaldsky, a Hungarian entomologist, *Arctopus ammophilus*, a species from southern Russia, feeds upon pods and seeds of medic (*Medicago sativa*), which the beetles collect during the night and heap up about their burrows in the ground.

Of the extreme variety of forms which species of Carabidae present, none is more remarkable than that of *Mormolyce*. The commonest species is *M. phyllodes*, a beetle often reaching three inches in length, and found in the forests upon the mountains of Java, where its remarkable form, best shown by the figure, has attracted the attention of the natives, by whom it is called *bibliotah'an*. Its antennae and legs are black; the rest of the beetle is pitch-brown, a little lighter in shade upon the margins of the elytra. These beetles, as well as their larvæ, are found about *Polyporus fomentarius*, a fungus upon the trunks of trees. The larvæ, which exhibit no remarkable structural peculiarities, and resemble those of *Carabus*, live within the fungus, feeding, it is supposed, upon the larvæ of other insects. Pupation takes place within the fungus, and the form of the elytra in the pupa indicates, to a certain extent, the remarkable form of the beetle that is to emerge from it. Larval life requires from eight to nine months; pupal life from eight to ten weeks. The imagoes are found mostly from August to November.

A large sub-family, the Harpalinae, includes such Carabidae as have the "middle coxal cavities entirely enclosed by the sterna, the epimeron not reaching the coxa; head without antennal grooves beneath, and supraorbital distinct setæ; ambulatorial setæ of abdomen usually well-developed."



FIG. 478. — *Harpalus caliginosus*.

The genus *Harpalus* includes a large number of flattened usually black beetles, of which it is often difficult to determine the species. Most of them have nearly square prothorax. Of the species of this genus *H. caliginosus* is very common in the eastern United States, often feeding upon the pollen and seeds of the common ragweed (*Ambrosia artemisiaefolia*). It is about an inch in length. A number of slightly smaller species are equally common, and have similar habits to the one last mentioned. Not very different from *Harpalus* in structure and habits are the many species of *Anisodactylus*. Still smaller than insects of the last-

mentioned genera is *Gymnandropus hylacis*, found in the eastern United States. This beetle is about 0.3 of an inch long. It is black above, and has brownish legs and mouth-parts; the elytra are striate. This beetle often abounds under the loose bark of hickory trees. Among other small carabids, which are not far from *Harpalus* in systematic position, are the species of *Agonoderus*. *A. lineola*, a very common little beetle about 0.35 of an inch long, which flies into the open windows in the evening, attracted by the lights within, is yellowish-brown, with black dots upon



FIG. 477. — *Mormolyce phyllodes*.



FIG. 479. — *Gymnandropus hylacis*.

the prothorax, and a stripe of the same color along the middle of each elytron. Much larger (about 0.6 of an inch), but of similar form, and pale-brown coloration, without distinct black markings, is *Geopinus incrassatus*, a common New England species. In *Geopinus*, *Agonoderus*, and other genera of the group to which they belong, the left mandible is longer than the right one, and overlaps it distinctly in the first-named genus.

The genus *Chlenius* includes beetles of medium size, which usually are of a greenish or purplish bronze color above. Sometimes the margin of the elytra or a few spots upon them are yellow. They frequent moist places beneath stones, and attain their maximum size and beauty in Africa. Most of the species have an odor somewhat like that of Morocco leather. *C. sericeus*, a bright green species, with brown antennæ and legs, is common along the banks of the larger rivers in the north-eastern United States. *C. tomentosus*, from the same region, is of a deep purplish bronze color.



FIG. 480. — *Chlenius sericeus*.

The genus *Brachinus*, already mentioned on account of its habits, consists of over 150 species distributed throughout temperate and tropical parts of the world. The beetles of this genus are mostly red, with blue or green elytra, and are found often in numbers together beneath stones. The species are very difficult to distinguish, but the genus is readily distinguished by its form, colors, and habits. The specific names *armiger*, *bellicosus*, *bombardus*, *crepitans*, *exhalans*, *explosivus*, *fumans*, *venator*, and the like, have reference to the habits of the bombardier-beetles.

Numerous small species of Carabidæ, which are much flattened, often ornamented with bright colors, and many of which frequent flowers, belong to the genus *Lebia*, in its older and less-restricted sense. *L. grandis*, one of the larger species of this genus, measuring about 0.4 of an inch in length, is yellowish-brown, with dark-blue elytra. This insect has proved useful by eating the eggs of the Colorado potato-beetle



FIG. 481. — *Lebia grandis*.

(*Doryphora decemlineata*). The genus *Coptodera*, of which *C. emarginata*, from Brazil, is figured, does not differ greatly structurally from *Lebia*. *Dromius*, another genus closely related to *Lebia*, has a heart-shaped prothorax. *D. picus*, a common North American species, is shining black and about 0.3 of an inch long. *D. quadrinotatus*, found in Europe, feeds, as larva, under the bark of pines, upon the larvæ of *Pissodes notatus*, a weevil.



FIG. 482. — *Coptodera emarginata*.

Of the genus *Galerita* there are five North American species. In the northeastern United States, *G. janus* is common under stones in early summer. Its length is about 0.75 of an inch; its antennæ, prothorax, and legs are red, and the rest of the beetle is bluish-black. The head is much elongated, and the prothorax is not half as wide as are the elytra, which latter are truncate at the tip. In *Casnonia*, which includes small beetles, the structure is quite similar to that of *Galerita*, but the thorax is very much more elongate. *C. pennsylvanica* is not rare under stones. Its length is about 0.25 of an inch, and its color is brown and black, the head, prothorax, and spots upon the elytra being of the latter color.



FIG. 484. — *Casnonia pennsylvanica*.



FIG. 483. — *Galerita janus*.

About eighty-five North American species of described Carabidae, which are considerably flattened, and resemble, to a certain extent, those of *Lebia*, but are not usually as vividly colored, and are generally somewhat larger, are included in the genus *Platynus*. The entire coloration of *P. cupripennis*, a North American species about 0.3 of an inch long, is metallic green with reddish reflections. *P. octopunctatus*, which is common in New England, although not as common as *P. cupripennis*, is similar in size and coloration to the latter species, but has four deeply impressed punctures arranged longitudinally near the inner margin of each elytron. Many of the species of this genus are black. Differing systematically from *Platynus*, in having the claws more or less serrate, is *Calathus*. In the last two genera the elytra are obliquely sinuate;



FIG. 485. — *Calathus impunctatus*.

but in *Lachnophorus*, of which *L. rugosus* from Brazil is figured, the elytra are round at the tip.



FIG. 486. — *Dicaelus purpuratus*.

Dicaelus comprises about twenty species of Coleoptera, all of which are North American. These beetles have the pronotum flattened, with a few slight wrinkles and an upturned margin; the elytra are striate. *D. splendidus*, from the southern United States, is over an inch long, and black with coppery-bronze elytra. *D. purpuratus*, a purplish-black species about an inch long; *D. elongatus* and *D. dilatatus*, both black, and 0.7 and 0.8 of an inch long respectively, are all found on the Atlantic slope as far north as Massachusetts.

Dr. G. H. Horn has described the larva of a species of *Dicaelus*, pos-

sibly of *D. dilatatus*. The body of the larva is dark greenish blue and semi-opaque, its head being reddish yellow. The larva is narrowed toward both ends; and the anal segment is armed with two slender inward-curved processes, between which the anus extends as a corneous tube equal in length to an abdominal segment. Its antennæ, although, as is usual in this family, four-jointed, are about one-third the length of the body. The legs increase in length from the first to the third pair. Pupation, which takes place beneath logs or in the ground, lasts but a week. Nearly related, systematically, to *Dicaelus* is *Badister*. *B. bipustulatus*, from Europe, is about 0.2 of an inch long, brown, with black head and two curved black lines on each elytron. Its larva has been described by Schödlte.



FIG. 487. — *Badister bipustulatus*.



FIG. 488. — *Pterostichus lucenblaudus*.

The genera *Pterostichus*, *Amara*, *Ecarthrus*, and *Loxandrus*, each contain numerous species; but they are separated with difficulty, and but little is known of their life history. Most of the species of these genera are black. A few have metallic colors, or vary from brown to red. Allied to these genera is *Zabrus*, of which *Z. gibbus* has already been mentioned on account of its destructiveness to crops. *Amara similata*, another European species, is said to eat both flowers and leaves of the shepherd's-purse (*Capsella bursa-pastoris*). To this same group of genera belong *Catadromus*, of which the Javanese *C. tenebrioides* is

figured on the plate.

Anophthalmus, already mentioned as a genus of blind cave beetles, contains about fifty species, of which seven are North American, being found in the caves of the Ohio Valley, and the rest European. The first North American species described was *A. tellkampfi*, from Mammoth Cave, in Kentucky. It is about 0.3 of an inch long,

slender and with long legs. Its color is light brown. This species is eyeless, although Grenier states that *A. aubertis*, from southern France, has minute non-pigmented eye-spots, and that these spots are black in *A. milleri*, from Hungary. The larva of an *Anophthalmus* from Mammoth Cave has been carefully described by Mr. H. G. Hubbard. The larva has no ocelli, and Mr. Hubbard writes of it that, "except in its very elongate form, I can find no striking differences between this and other Carabid larvæ allied to *Trechus*." *Trechus* and *Patrobus* are genera which are closely related, systematically, to *Anophthalmus*, but which have eyes.



FIG. 489. — *Trechus rubens*.



FIG. 490. — *Patrobus rufipes*.

A large number of small beetles, which scarcely ever exceed 0.25 of an inch in length, and many species of which are found running about in the sunlight upon the sand of river banks and of the shores of lakes, are included in the genus *Bembidium* in its wider sense. In proportion to their size these beetles are among the quickest running insects, and considerable dexterity is necessary to capture them. The species of *Tachys* are even smaller than those of the last-mentioned genus, which they resemble in habits.



FIG. 491. — *Bembidium laevigatum*.

Morio georgie, which is black and about 0.5 of an inch long, is the single representative in the United States of the tribe of insects to which it belongs, of which a few species are found in most parts of the world. It is found in the southern States.

The sub-family Carabinae, which includes the larger and more beautiful species of Carabidæ, are characterized as follows: "Middle coxal cavities not entirely enclosed by the sterna, the epimeron of the mesosternum reaching the coxa." The genera are more easily recognized in this sub-family than they are in the preceding one, and their characters will be given, following, as usual, the authoritative work for North American Coleoptera, Drs. Le Conte and Horn's classification.



FIG. 492. — *Morio georgie*.



FIG. 493. — *Scarites subterraneus*.

In the tribe of which *Scarites* is the typical genus, the posterior coxæ do not attain the side margin of the body, the anterior coxal cavities are closed behind, the prosternum does not conceal the mesosternum, the antennæ arise either under a distinct frontal plate or a ridge which extends backward over the eyes, the body is pedunculate, and the posterior coxæ are contiguous. In *Scarites* itself the hind angles of the thorax are wanting, the elytra are without a humeral carina, the maxillæ are slightly hooked at the tip, and the basal joint of the antennæ is long. *S. subterraneus* is a very common species in New Eng-

land, and is from 0.7 to 1 inch in length, with large mandibles. It is said to live in the burrows of *Copris*, a scarabæid, and probably devours coprophagous larvæ. *Monhotia gloriosa*, a species from southern Europe, which is similar to *Scarites*, attains a length of over two inches. *Pasinachus* differs from *Scarites* in having the hind angles of the thorax distinct, the elytra with a humeral carina of variable length, and the maxillæ very obtuse at the tip. The species, which are usually margined with blue, are all North American. *P. depressus* is of a dull black color, without striæ or punctures, and is found in the southern United States.



FIG. 494. — *Pasinachus depressus*.

Metrius contractus, from California, is the single species representing a tribe which differs from *Scarites* in having the body not pedunculate and the posterior coxæ separated. This beetle is found under stones in forests.

The genus *Elaphrus* differs from the genera of Carabina already mentioned in having the antennæ free at the base. In this genus the form is robust, the mandibles have a setigerous puncture, and the elytra are marked with impressed spots. The species of this genus are found running about in the sunlight on the surface of the mud around the borders of ponds and pools. The color of many of the species is a purplish or greenish bronze. *E. riparius*, which is figured, is about 0.25 of an inch long, and is common in parts of Europe. In *B.*



FIG. 496. — *Elaphrus riparius*.

thisa the elytra have striæ between the impressed spots.

B. multipunctata is a European species that has been found in America. According to Laudoit, *E. riparius* and *B. multipunctata* stridulate

by rubbing the upper side of the penultimate abdominal segment against the inside of the elytra, both the parts rubbed together being provided with surfaces suitable for sonification.

The typical genus of this family is *Carabus*, which is represented in North America by only about ten species, reaches its highest development in Europe, where a large number of species are found. In this genus the anterior coxal cavities are open behind, the posterior coxæ are contiguous, the labrum not bifurcate, the mandibles without a setigerous puncture externally, and the third joint of the antennæ cylindrical. Most of the species are of medium, some of large size,



FIG. 498. — *Carabus serratus*.

and many have beautiful coloration. Their food consists of earthworms, caterpillars, and other insects. The species of *Carabus*, and those of the allied genera *Calosoma* and *Cychrus*, have well-developed anal glands, and throw a strong acid fluid. *C. serratus* is the most abundant species in the northeastern United States. It is from 0.60 to 0.75 of an inch long, is black, with the upturned margins of the prothorax and elytra bluish, and its elytra are punctate. *C. sylvestris*, from the same region, is similar to *C. serratus*, but larger, being about an inch long. One of the prettiest of the common European species is *C. auratus*, which is nearly an inch in length, and has the entire upper surface greenish bronze with a reddish reflection.

In *C. glabreatus*, another European species, the elytra, which are often conate in this genus, are so firmly united that the suture between them is scarcely noticeable. *C. hispanus*, from Spain and southern France, is about 1.4 inches long; and the elytra are coarsely punctured, and reddish bronze margined with blue, while the head and the prothorax are metallic blue. *Procrustes* differs but little from *Carabus*. *P. coriaceus*, a black species, nearly 1.5 inches long, is found throughout southern Europe.

Calosoma differs generically from *Carabus* in having the third antennal joint compressed. The habits of the species of this genus are very similar to those of



FIG. 495. — *Metrius contractus*, enlarged.



FIG. 497. — *Blithisa multipunctata*.

Carabus. In the United States *Calosoma calidum* and *C. scrutator* have been observed to eat canker-worms (larvæ of *Anisopteryx*), and the larvæ of *C. externum* prey upon army-worms (larvæ of *Leucania unipuncta*); in Australia the larvæ of *C. curtisii* live beneath cow-dung, where they probably feed on noctuid larvæ; and the larvæ of several species of *Calosoma* devour snails. The commonest species of this genus in the eastern United States is *C. calidum*, which is about an inch long. Its elytra are covered with large bronze-colored punctures, the rest of the insect being black. Professor



FIG. 499. — *Calosoma calidum*.

A. S. Packard states that he has seen this species attack the June-bug (*Lachnosterna fusca*) and tear its sides open. The larva of *C. calidum* is black. The most brilliant species of this genus that inhabits the eastern United States is *C. scrutator*, which measures a little over an inch in length. The elytra are metallic green, margined with a narrow line of reddish bronze; the prothorax is deep shining blue with the channel formed by its up-turned edges paved with reddish bronze. This species is said to climb trees in search of larvæ. In Europe *C. sycophanta* resembles quite closely *C. scrutator*, but lacks the reddish-bronze margins of the prothorax and elytra.



FIG. 500. — *Calosoma scrutator*.

The species of *Cychnus*, which are distributed by some authors into several genera, differ from those of *Carabus* and *Calosoma* in having the posterior coxæ separated and the labrum bifurcate. The antennæ have four basal joints glabrous. The larvæ of *Cychnus* are said to be distinguished from those of *Carabus* by their brown color and by the four teeth with which the last abdominal segment is armed in place of the two horns so common in carabid larvæ. The generally elongated anterior parts of these beetles well fit them for their mode of life, enabling them to reach deeply into



FIG. 501. — *Cychnus elevatus*.

the shells of snails, on which they feed. The flattened, often broadly triangular apical joints of the palpi of these insects apparently co-operate with their elongated mandibles in extracting the soft tissues of snails from their shells. *C. stenostomus*, of which *C. lecontei* is a variety, is found in the eastern United States, and is of a bluish-black color. *C. elevatus* has the posterior angles of the black thorax margined, and the margins elevated to meet the elevated margin of the anterior part of the coppery-bronze elytra. This beautiful species is rare in New England, but more common to the southward and westward. Its length varies from 0.6 to 1.1 inches. The only specimen that I have taken in New England

was found in northern Connecticut, eating a species of freshly killed *Helix albolabris*. The largest species of *Cychnus* found in New England is *C. viduus*, which varies from 0.70 to 1.16 inches in length. *C. rostratus* is found in many parts of Europe.

The genus *Omphron* includes a small number of flattened, nearly round beetles, which live in moist places. The anterior coxal cavities are closed behind, the prosternum is prolonged and dilated so that it entirely conceals the mesosternum, and the



CARABID BEETLES.

1. *Calosoma sycophanta*. 2. *Cistonia*. 3. *Tachyporus rugosus*. 4. *Elephrus riparius*. 5. *Cyphrus rostratus*.
6. *Citadromus tenebrioides*. 7. *Callistus quadripustulatus*. 8. *Panagaeus luniculosus*. 9. *Scaphites goudotii*.
10. *Onychopteris fulgens*. 11. *Procrustes coriaceus*.

scutellum is completely concealed. The species are usually marked with dark brown and yellow.

The last family of beetles to be considered is the *CICINDELIDÆ*, which, not only on account of its structural peculiarities, but also because of the exclusively predaceous habits of its species, is generally considered the highest family of *Coleoptera*. The special character by which they are separated from the *Carabidæ* is the place of insertion of the antennæ. In the *Cicindelidæ*, these organs are inserted on the front above the base of the mandibles. The general

form and usual pattern of coloration of the insects of this family serve to make them easily recognized. In a few forms the elytra are connate and the wings absent, but most of these insects both run and fly rapidly. Many of the species live on the sandy banks of rivers and of the ocean, some

tropical species live in trees, and a few abound in open places in the woods. Coquerel states that *Cicindela trilinearis*, from Madagascar, has the power of running upon water. Species of *Megacephala* are crepuscular, remaining in their holes during the day, and running about on the sand just before and after sunset. Bates states that *Tetracha nocturna* and *T. pallipes* are nocturnal in habits. The former species is of the color of the sand upon which it runs, and is thus protected from insectivorous birds. *T. pallipes* is, on the contrary, brilliantly colored, and owes its protection from insect-eating animals to its very strong, disagreeable odor.

The larvæ of *Cicindelidæ* live in holes in the ground, the holes being, in some species, a foot and a half in depth. The larvæ have four-jointed antennæ, three-jointed maxillary palpi, and two-jointed labial palpi. Upon each side of the head are the ocelli, which are two in number in *Amblychila* and eight in species of *Tetracha*, *Omus*, and *Cicindela*. These larvæ are assisted in their motions up and down their burrows by a pair of protuberances which are armed with hooks. When waiting for prey these larvæ rest at the top of their burrows—their metallic-colored head and prothorax serving as operculum for the entrance to their burrow—with their sickle-shaped mandibles wide open. When the larva has made a capture of some insect that incautiously attempted to run over its head, it retires into its burrow to eat its prey at its leisure. It is said that the larvæ of *Cicindela campestris*, a European species, leave their holes at night to search for prey.

Of the group of *Manticorini*, those *Cicindelidæ* that have the posterior coxæ separated, the eyes small, and wings absent, only two genera are found in this country, both of which are confined to North America. In *Amblychila*



FIG. 503. — *Megacephala phalerata senegalensis*.



FIG. 502. — *Manticora maxillosa*.



FIG. 504. — *Amblychila cylindriciformis*.

the elytra are widely inflexed, the prothorax scarcely margined, and the terminal joint of the maxillary palpi shorter than the third joint. *A. cylindriciformis*, the only species, is found in Kansas, New Mexico, and Arizona. It is the largest species of this family found in the United States, and is brownish-black in color. Its habits are nocturnal. In *Omus* the elytra are narrowly inflexed, the prothorax distinctly margined, and the last two joints of the maxillary palpi subequal. The nine described species are all from the Pacific slope of North America, and are nocturnal.



FIG. 505. — *Omus dejeani*.

In *Tetracha*, the only representative of the Megacephalini found in the United States, the eyes are large and prominent, the posterior coxæ contiguous, and the third joint of the maxillary palpi longer than the fourth. *T. virginica* is dark metallic green above, with light brown legs and antennæ. Its length is about 0.75 of an inch. It is found in the southern Atlantic states concealed under logs and bark by day, for its habits are crepuscular. *T. carolina*, which has a yellow spot near the apex of each elytron, and is about 0.6 of an inch long, is widely distributed over America, from the middle United States to Chili and Peru.



FIG. 506. — *Tetracha carolina*.

The Cicindelini are represented by about sixty North American species of *Cicindela*. In these insects, the third joint of the maxillary palpi is shorter than the fourth. The five species of *Cicindela* figured are all common in the northeastern United States. Their size and figuration are well illustrated in the cuts. *C. sexguttata* is very bright metallic green, often with a bluish lustre, and the yellow spots upon its elytra are subject to some variation. This species, like the next, frequents sunny roads in the woods, where the grass is worn down quite short. *C. purpurea* is purplish-bronze color, with the lateral margin of the elytra metallic green, and the markings upon the elytra yellow. *C. generosa* is coppery bronze color, with the yellow elytral markings extending as an outer margin



FIG. 507. — Tiger beetles. a, *Cicindela generosa*; b, *C. tranquebarica*; c, *C. purpurea*; d, *C. hirticollis*; e, *C. sexguttata*.

around the elytra, and *C. tranquebarica* and *C. hirticollis* are of dark bronze color, sometimes almost black, with yellow markings on the elytra. *C. generosa*, *C. tranquebarica*, and *C. hirticollis* frequent sandy river banks. In *C. dorsalis*, which swarms along the south coast of Long Island, the elytra are nearly white, and the purplish prothorax is clothed with white scale-like hairs. This coloration is evidently protective; for these beetles are very difficult to see upon the white sand of the seashore, and still more difficult to capture, as they fly, without the slightest hesitation, directly out over the surf.

GEORGE DIMMOCK.

ORDER VIII. — DIPTERA.

If we take into account the number of individuals, with the number of species, there is no order of insects so extensive as the Diptera, or two-winged flies. Among them are found many that affect man's economy or well-being very greatly. It is needless to point out some of these, such as the mosquito, house-fly, bot-fly, black-fly, etc., but others, whose injury or benefit can hardly be estimated, are far less familiar to the ordinary observer. Many, indeed most of the species, are small or inconspicuous, and have but little, either in form or color, to attract the entomological collector.

They may be distinguished almost invariably by the presence of a single pair of wings, and never more. The second, or hind pair, corresponding to those in other insects, are aborted into small organs, called the halteres or balancers. These have a slender stem, terminating in a rounded head, and are constantly in vibration during flight. Their function is unknown, though it has been thought that they are organs of sense. The muscles for the front pair of wings are hence alone developed, and the thorax is, in consequence, more globular, and composed chiefly of the mesothorax. The prothorax is confined to a ring or collar on the front part of the thorax, inconspicuous, or not visible from above. It may be most readily distinguished in the Bibionidae and Tipulidae. The metathorax is yet more aborted and confined to the lower and hind portions; the so-called metanotum has been shown by Hammond to really belong to the mesothorax. The scutellum, cut off by an impressed line, is an oval or semi-oval portion on the hind part above. The sides of the thorax, or pleuræ, are seen to be divided into irregular spaces by sutures, corresponding to the divisions in other insects, each of which has received a name according to its position.

The legs, which generally are rather weak or slender, but sometimes stout, are attached to the thorax, through the intervention of the ring-like trochanters, by means of the conical, sometimes elongated coxæ. The femora, tibiæ, and tarsi not infrequently show structural or ornamental characters peculiar to one sex. Such may consist of spurs, teeth, thickness, or elongation, tufts, or discs of hairs, etc., and are most usually confined to the male. The tarsi are almost invariably five-jointed, the last of which terminates in two claws, on whose under sides are usually two or three membranous appendages, called the pulvilli, that serve as aids in climbing or grasping.

The single pair of wings are rarely aborted or wholly wanting, as may be seen in *Chionea*, a wingless genus of Tipulidae, or the sheep and bat ticks. More rarely they are wanting in one sex only, while in the other they may be complete or rudimentary. They are thin, membranous, and in some, as the common housefly, capable of extreme rapidity of vibration, as many as three or four hundred a second. They are generally

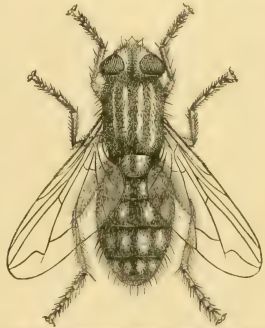


FIG. 508.—*Sarcophaga carnaria*, common flesh-fly.

transparent, though sometimes prettily spotted or more or less colored. They are naked or clothed with microscopic hair, and supported by a system of longitudinal and transverse veins, which are always present though varying much in number and intricacy; in some species, as the Tipulidæ and Nemestrinidæ, almost Neuropter-like in their reticulation, while in others, as especially the Cecidomyidæ, there may be only three or four weak longitudinal veins present. Some of the most important family characters are drawn from the number and arrangement of the veins, especially on the basal part of the wing, while the outer portion may furnish very valuable generic characters.

The head has a very free union with the thorax by means of the slender neck. It varies exceedingly in shape, and, as would be supposed, furnishes many of the characters for classification. It is more usually hemispherical, with the occiput flattened or even concave, but often is spherical or conical and sometimes with lateral prolongations upon which the compound eyes are situated.

The eyes are almost always well developed, comprising a large part of the head or indeed often much the largest part; they are composed of a great many separate lenses or facets, which in not a few are enlarged in areas in the male and are often with brilliant markings. As a general rule the eyes in the male approach each other, or are contiguous, above, leaving only a small space at the vertex and another below near the antennæ. At the vertex there are generally three simple eyes, or ocelli; their presence, however, is inconstant in closely allied forms sometimes, and cannot hence be of important use to such.

The antennæ vary much in structure and are very useful, both in distinguishing the higher and lower groups. They are usually situated near the middle of the head in profile, though they may be placed above near the vertex, or below near the mouth. Until recently, and yet by many entomologists, all Diptera were divided into two sub-orders, according to the structure of the antennæ. In those of the first division, the Nemocera, the antennæ are thread-like, consisting of from six to thirty-six joints, all of which, except the first two, being alike in structure, and often with a circle of hairs on each joint. Of this group the mosquito will readily serve as an example. Under the Brachycera were placed those families among which the antennæ consist only of three joints, and the additional ones, whether distinct or styliform, or most frequently bristle-like, are considered only appendages of the third joint. In the most typical forms, such as the housefly, the antennæ are quite short, composed of three simple joints, the last of which has a slender bristle on its upper border. This bristle, which frequently is ornamented feathery-like, is more or less distinctly jointed, and in reality corresponds to the additional joints of the first sub-order. It is true it may be situated close to the base of the elongated joint, but this is due to the fact that this joint is chiefly or almost wholly developed from below. Although these two general divisions may seem useful enough when the more typical forms alone are observed, yet intermediate forms are such as to render the division unnatural and indefinite. At present a more natural division is that proposed by Brauer, based chiefly upon the study of the metamorphoses in the immature stages, and which will be defined further on.

The mouth parts of Diptera are wholly suctorial, and differ from those of Lepidoptera in that all of the component parts may be brought into use. They differ not a little, however, in different flies, as might be supposed from their diverse habits. In some they are adapted for piercing animal or vegetable substances, and are, in con-

sequence, firmer and more slender; in others, and by far the greater number, they are adapted only for sucking up juices or such substances as may be dissolved by means of their saliva. Grains of pollen have been observed in the digestive organs of the Syrphidae, and other flower flies, but, as a rule, fluids alone serve as food. Many have the proboscis wholly retractile into the oral cavity, and furnished with one or even two hinges, by which when at rest it may be folded up. In others the proboscis is not retractile, and either projects in front or backwards under the abdomen. While it is usually short, it may be as long or longer than the body. Finally, a few species have the mouth parts rudimentary, and take no nourishment in the adult stage.

The different parts consist of the labium, the maxillæ, maxillary palpi, mandibles, hypopharynx and labrum-epipharynx, a term used by Dimmock, to whom our clearest knowledge of the mouth parts of Diptera is due.

The labial palpi are thought to be wholly wanting. The labium is always present, more or less fleshy and provided with muscles, and is grooved or channelled upon the upper side to receive the other parts in a sheath completed by the labrum. At its tip there is a pair of joints called the labelle. In the mosquito these are small, where they serve simply to guide the piercing portion between them, the labium itself being bent backward beneath the thorax in its middle. Very often they are large and more fleshy, and on the inner sides have a roughened surface composed of the pseudo-tracheæ which, as in the housefly, serve as means for attrition. The maxillæ and mandibles are frequently absent, the latter most often; when present they are slender and bristle-like. The maxillary palpi are always present and consist of from one to five joints, in the latter case often long and whip-like; they are more or less hairy, and are attached near the base of the proboscis on the outer side where the maxillæ coalesce with the labium. In addition to the two pairs of maxillæ

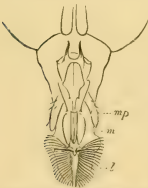


FIG. 510. — Mouth-parts of house-fly; *l*, labelle; *m*, maxillæ; *mp*, maxillary palpi.

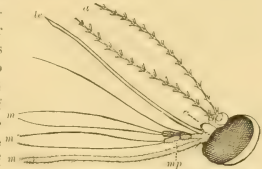


FIG. 509. — Head and mouth-parts of *Culex rufus*; *le*, antennæ; *le*, labrum-epipharynx; *h*, hypopharynx; *m*, mandibles; *me*, maxillæ; *l*, labium; *mp*, maxillary palpi; *c*, clypeus.

illæ and mandibles there is a third, unpaired, slender organ which is free, the hypopharynx. It is usually present and tube-like for the passage of saliva, the outlet being near the tip on the upper side; its tip may be smooth, lance-like, or hairy. Its upper side is continuous with the under surface of the pharynx, and the whole, or in part may coalesce with the labium below. Finally, the largest, except the labium, and uppermost, as well as most important organ, is the labrum-epipharynx, which is deeply channelled on the under surface and converted into a canal by the apposition of the hypopharynx below. It is through this channel that all the substances used as food must pass. The two parts of which this organ is composed, the labrum above and the epipharynx below, are sometimes separable by the means of caustic potash, but are never so in

life. It may terminate in a single point or in several minute ones as in the mosquito. It forms, as before stated, a covering to the channel in the labium, and may be separable at the will of the insect as is readily seen in the mosquito when biting, or it may always remain tightly closed, as in the housefly.

The abdomen varies much in shape, being short, broad, slender, elongate, or even wasp-like. At the tip the male organs (hypopygium) are often small, at other times large, conspicuous, and complicated. In the female the last two or three segments form a simple ovipositor, in most small and retractile, but not infrequently elongate, and it may be as long as the entire body. Usually the eggs are deposited on the surface of such substances as will serve for the future food, or are easily penetrable by the larvæ, and hence it is rare that any thickening of the ovipositor or terminal segments is necessary.

On one side of the œsophagus there is a sucking stomach, as in the lepidoptera, and there are four, or rarely five, Malpighian glands corresponding to the kidneys, which discharge the secretion into the intestine through one or two common outlets. The tracheæ, by which they breathe, consists of two bladder-like air sacs, situated one on each side of the base of the abdomen. The nervous system is composed of a chain of ganglia, in some species numbering nine or ten, while in others, the more specialized and highly developed, the whole nervous system may be confined to a single ganglion in the thorax, from which nerves proceed to the abdomen.

The larvæ are usually wholly footless maggots, moving by contraction and extension of the segments, or by leaping, as in the cheese-fly. They never have distinctly differentiated thoracic legs, although often with a pair of protuberances on the first segment, or, as in the *Cecidomyiæ*, there may be a single unpaired hardened chitinous spot on the third segment, that serves as means of locomotion. There are often false abdominal legs that may be either distinct or merely swellings covered with bristly hooklets. They are either wholly headless, with an oral opening alone, or the head may be partly or completely differentiated, with the mouth-parts rudimentary or complete. The eyes, which when present are always simple and inconstant in their position, are often wholly wanting.

The metamorphosis is complete, and takes place chiefly in two different ways, which have so far furnished the best general division for the order, and yet one that is not wholly free from objections. In the first division, the *Orthorhapha*, which includes all the nematocerous flies, and some other families, the pupæ may be either free, as most usually is the case, or included in the larval skin, — the so-called puparium, or the larva pupigera, — but, except in the pupigerous *Cecidomyiæ*, the larval skin when it bursts does so in a longitudinal rent on the back of the front end, and with another, a transverse one, forming a T-shaped opening. In the other group, which are always pupigerous, the perfect insect escapes from the larval skin through a more or less circular opening at the anterior end, composed of the first two or three segments, and forming a sort of a lid or cover. This sub-order is thus called *Cyclorhapha*. The flies force the opening of this larval envelope by means of a large bladder-like inflation or swelling on the front, and such flies have a curved space, the frontal lunule, immediately above the antennæ, that is wanting in the other group. This division includes the larger part of the brachycerous flies.

The larvæ, as in the adult stages, breathe by means of stigmata, small openings frequently placed along the sides, two on each segment; but in a larger number, including all the legless maggots, they are situated near the end of the body. In some, as in also some of the larvæ with heads, the stigma terminates in an elongated tube at the hind end; such are aquatic in habits.

In the pupa stage the legs are not movable, or, if they are, the pupæ are not free but are included in the larval skin, which, by contraction, forms a free, loose envelope,

the so-called puparium. The pupæ may be very active, but in all such cases the motion is produced by movements of the abdomen alone, and by these means the insects find their way out of the earth, or are adapted for a free aquatic life. Those that are inactive are chiefly those contained in the larval envelope, the larvæ pupigeræ.

In Europe over nine thousand species of flies are known, and altogether there have been described nearly twenty-five thousand. From North America nearly four thousand names have been given.

As very many species are small and inconspicuous, and not a few minute, it is certain that in Europe, where they are best studied, there are many yet to be found. As evidence of this it is only necessary to mention that not many years ago Winnertz described as new nearly one hundred and fifty species of the single genus *Sciara* from Europe. At least seventy-five, and probably one hundred thousand species, seems to be a fair estimate of this order occurring throughout the world. In their geographical distribution they show few striking points of interest; there are comparatively few genera peculiar to any one continent, and many species are widely distributed, some indeed almost the whole world over. They are found in all portions of the earth where man has ever been, though they flourish best where vegetation most abounds. In geological distribution they do not extend very far back in time, the first reliable remains occurring in the Jurassic beds of Solenhofen. In the tertiary times, however, remains of the order are found in large quantities; in North America many have been described by Scudder from the Rocky Mountain deposits. Wherever they are found they show but little variation from the types now living.

As a rule flies prefer the bright sunshine, or sunshiny weather, disappearing from view in cloudy days and at night-time. Some, however, like the mosquitoes and their allies, fly mostly at night. Their habits vary much; the larger number live about flowers, feeding upon pollen and honey; whole families, however, are carnivorous, living upon the juices of other insects or of vertebrate animals. As a whole, the order is a beneficial one to the human economy. While we may resent the impertinent mosquito's and the troublesome housefly's molestations, and while the black-fly and horse-fly may cause the death of many horses and cattle, yet the larger number are purely parasitic in their habits, either in the larval or adult states, upon other and usually injurious insects. Many others, too, act as beneficial scavengers of unwholesome matters, which would otherwise often bring disease and death.

SUB-ORDER I. — ORTHORHAPHA.

In this division the pupæ escape from the larval skin through a T-shaped orifice, or rarely through a transverse rent between the seventh and eighth abdominal rings. Pupæ chiefly free. Adults wholly without a lunula above the antennæ.

SECTION I. — NEMATOCERA.

Antennæ usually many-jointed, the joints, except the basal two, alike, often fringed with hairs or bristles; palpi often four or five-jointed and elongated.

The family MYCETOPHILIDÆ, commonly called Fungus Gnats, in which the species are usually small or minute, comprises about seven hundred described species, and probably several times as many in reality. The larvæ live chiefly in fungi and decaying wood or other vegetable matter. They are usually elongate and cylindrical, bare, with a

head, usually without eyes, more or less worm-like in appearance. Some resemble snails somewhat, and may construct for themselves delicate silky cocoons; a few species form galls. The wings of the adult fly have but few veins and no discal cell, which together with the elongate coxæ will render these flies easily distinguishable. Usually there are ocelli present, and the tibiæ are all armed with spurs. The flies are small, active usually, leaping about by the aid of their hind-legs.

The larvæ of one genus, at least (*Sciara*), have long been known for their gregarious habits. They are often found in dense patches under the bark of trees, and, what is more interesting, when about to change to the pupa state, will congregate in immense numbers, forming processions that have been observed four or five inches wide and ten or twelve feet long. They travel in a solid column from four to six deep, over each other, advancing about an inch a minute. From this peculiar habit, they have been called the army-worm in Europe. Similar habits have been observed in this country among our species. One species of this genus (*S. mali*) is known to feed in numbers in the interior of apples in this country.

The species of *Mycetobia* figured was seen in abundance by Packard "in the crevices of the bark of an elm from which flowed a sour sap mingled with dust, and in this putrescent mass the slender white larvæ were seen gliding about."



FIG. 511. — *Mycetobia sordida*. a, larva; b, pupa enlarged.

Among all the flies that constitute this group, there are perhaps none so injurious as the *CECIDOMYIDÆ*, or gall-flies. The family contains a large number of extremely delicate and very minute species, clothed on the wings

and other parts of the body with long hairs, which are easily rubbed off. There are no ocelli, the thorax is without a transverse suture, the coxæ are not elongate, the femora not thickened, and the tibiæ are without spurs. The wings, moreover, contain but very few veins, there being only three or four longitudinal ones apparent.

The family must embrace a very large number of species, but owing to the unavoidable difficulties that their study must always present to the pure systematist, a thorough knowledge of them will be obtained very slowly. At present less than six hundred are known. The knowledge of our American species is chiefly due to Baron Osten Sacken, to whom, more than any one else, the science of American dipterology is owing. The following account of the larvæ is taken largely from his writings.

The egg of *Cecidomyia* is elongated, rounded at both ends, orange yellow or whitish. The time when the larva is hatched varies much, and depends upon the state of the weather, sometimes requiring only a few hours, but more generally a few days. When first hatched the larva is colorless, transparent, with a translucent green, yellowish or red stomach; late in life it assumes different shades of red, or becomes yellow, or whitish. All these larvæ have the extraordinary number of fourteen segments, thus affording an apparent exception from all the larvæ of insects, which as a general rule have thirteen. This supernumerary segment is placed between the head and the first thoracic segment. The larvæ have nine pairs of stigmata along the side of the body, apparent as long, more or less nipple-shaped projections. The head is not differentiated; the jaws are rudimentary, and there are large two-jointed palpi. On the second segment above there is a pigmentary eye spot. Below, on the same segment, there is, according to the age and species of the larvæ, a more or less developed

hardened, chitinous spot, the so-called 'breast-bone,' which is retractile into a transverse cleft, and serves for locomotion. The skin is very finely roughened or smooth, and some have, in addition to the breast-bone, false abdominal legs. The last segment is smooth or rounded, or furnished with two elongate tubercles, sometimes uneven and bristly, or armed with a pair of horny processes, frequently curved upwards, that may serve as aids in leaping, which is effected by pressing these horny hooks against the under side of the thoracic segments. Their motions, except those few which live on the surface of leaves, are generally slow; but those which change their abode before assuming the pupa state become very active about this period. A very great activity was observed by Winnertz in some such larvæ after a thunder-storm. They left their hiding places under ground and crawled about restlessly for some time; repeating these actions after every thunder-storm, some of them even two months after having left their galls.

Owing to their rudimentary jaws it seems evident that the larvæ must feed upon juices only, and that they require but little nourishment is shown by the fact that they attain their full growth and development in a gall just large enough to enclose them, apparently hermetically sealed, and for the most part with hard walls. It is most probable that they absorb nourishment in a quiescent state. As many as sixty are known to live in a single gall. What causes the galls is not so easy to answer; probably some peculiar irritation produced by the insect.

Most of the species live exclusively on a single kind of plant, or at least closely allied plants. The greater number penetrate the inside of the plant so as to be concealed from view during their development. Their presence is generally indicated on the outside of the plant by some deformation. Every part of the plant from the flower to the roots is liable to such attacks, but each species attacks the same part of the plant and deforms it in the same manner.

The larvæ are, unlike all the allied families, often pupigerous; that is, the larval skin contracts to form an envelope for the enclosed pupa. They, however, differ from the cyclorhaphous larvæ pupigeræ in that the fly does not escape through a circular opening at the anterior end, but the abdomen is protruded through a transverse opening between the seventh and eighth segments, the head escaping last. Some of the larvæ form cocoons for themselves before undergoing their final transformations. They have been observed by Winnertz, when fastened to a leaf, to become encircled in twenty-four hours by a white halo, consisting of tiny, thread-like particles; which seemed to grow somewhat like crystal particles; the larvæ during the time remaining perfectly motionless. The cocoon was perfected in a few days, but even then, though examined under a strong magnifying power, no genuine thread was perceptible.

A most remarkable fact in the biology of these insects was discovered by Wagner, in 1860. According to this scientist the larvæ of certain species, which he placed under the genus *Miastor*, and which live under the bark of trees, produce from ovary-like organs a number of eggs, which hatch within the abdominal cavity of the parent and here remain awhile, feeding upon the tissues that surround them until they have been consumed; they then escape to increase in size and produce another generation in the same remarkable manner. These series of sexual reproductions are continued from the autumn to the following



FIG. 512.—Paedogenetic larva of *Miastor*, *a a*, pseudovaria and pseudova.

spring, when pupæ are produced from the last brood which undergo their transformation into the sexual forms, and from which a new series of eggs, agamic broods of larvæ, and pupæ in their turns result.

Several species of this family are very destructive to some of our useful plants. The most important of these is *Cecidomyia destructor*, commonly called the Hessian

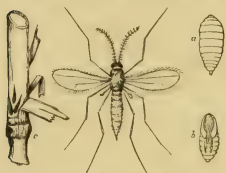


FIG. 513. — *Cecidomyia destructor*, Hessian fly; a, larva; b, pupa; c, pupæ on wheat straw.

fly, from the belief, probably erroneous, that they were first introduced into this country in straw with the Hessian troops at the time of the Revolution. The fly is very small, but little more than the eighth of an inch in length, of a prevailing opaque black color, with the abdomen below chiefly, and above with transverse and longitudinal lines, blood red. They seem very insignificant, yet in many years their devastation in fields of growing grain can only be reckoned by the thousands, if not by millions, of dollars. There are two broods, in spring and autumn. The female deposits her eggs,

one or two at a time, on the upper sides of the leaves, to the number of from eighty to one hundred. These eggs are very minute, not more than the fiftieth of an inch long; in from four to eight days, if the weather is not too cold, they hatch. The very small, yellowish red larvæ then crawl downward on the leaves till they insert themselves in the sheath between the leaf and the stalk. Here they remain quiescent, growing by means of absorption, or imbibition of the juices of the plant, till they reach the size of a small grain of rice. When a number, as it usually happens, become thus imbedded in the growing stalk, they not only cut off the flow of sap to the grain above, and thus cause the kernels to be illy filled out, but they weaken the strength of the plant, so that rains and storms cause them to be beaten down and so perish. The larvæ that are hatched in April, in a few weeks, or by the latter part of June, assume the pupa state, called the flaxseed stage; the larval skin becomes firmer and brown, enclosing the true pupa, and in size is like a grain of rice. In August the second brood appears, the female of which deposits her eggs in the young winter wheat or other grain, where the larvæ soon hatch and acquire the flaxseed condition in November, in which state they pass the winter.

Small as are these flies, they are preyed upon in the early stages by hymenopterous parasites, which destroy the greater portion. The most important of these is the minute Chalcid, *Semiotellus destructor*.

Another species, *Diplosis tritici*, is, in both Europe and America, destructive to grain, but its habits are very different. The female, likewise a very small fly, deposits her eggs, from three to ten in number, within the head or ear of wheat, or in default of this, in wild species of the same genus, *Triticum*. In about eight days the eggs hatch, and the larvæ, creeping about, suck out the juices from the tender kernels. In about three weeks the larvæ escape, and burrowing from one to four inches deep in the ground, remain for about two weeks more, when, coming near the surface, they shed the larval skin and become pupæ; here they remain till the next season.

Still another species, which, although it has not yet received a name, has been observed of late years in some places destructive to the cranberry. The writer has seen in the latter part of June large meadows in which nearly every plant was infested by one or more delicate silky cocoons, attached to the terminal leaflets,

causing them to wither and die. A number collected in the last week of June hatched about the 8th of July.

The family SIMULIDÆ comprises but a single genus and about sixty known species. The flies are small and short, and resemble the species of the next sub-order more. There are no ocelli, the thorax is without a transverse suture, the legs short, tibiae without spurs, and the hind tibiae and the first joint of the hind tarsi are dilated. They rarely exceed five or six millimetres in length.

The larvæ all live under water, usually of mountain or running streams, and they are interesting little creatures. They are soft-skinned, thinner near the middle. They have a cylindrical head, and two pairs of eye spots. On the first thoracic segment there is a foot protuberance with bristly hooklets, and the end of the abdomen has several appendages for attachment. They live on sub-aquatic stems of plants or on stones, where they form for themselves elongated cocoons open above. In this upper end the pupæ ensconce themselves with the anterior part of the body naked and free, from which extend eight or sixteen very long, slender, thread-like breathing-tubes. The perfect insect escapes under water and crawls to the surface.

Many of the species are black, and known under the name of "black flies"; in South America some are called mosquitoes. But wherever they are found they (or rather the females, for the males are harmless) are troublesome enough, and in places do much damage.

The European species that is best known (*Simulium columbaczense*) is most common in the regions of the Danube, especially towards the mouth, where their dreaded appearance in certain springs spreads dismay and fear among both men and beasts. In some years, which fortunately do not recur very often, many hundreds of cattle fall victims to their bites. Wherever they bite they are said to cause not only a burning itching but also very soon a painful hard swelling that may remain for a week or more. Many such bites close together produce a severe inflammatory fever, and, in the more susceptible, cramps. The flies seek parts of the body which are thinly clothed with hair, but especially will they endeavor to crawl into the various passages, particularly the nose, where they will be found in such great numbers at the death of the animal as to form layers.

In America an allied species yet unnamed is quite as troublesome in our Southern States; it is called the "buffalo gnat." The following account has been sent the writer by Mr. Brodnax of Louisiana: "These gnats are found here in greater or less numbers every year, but they only occur in such incredible quantities but rarely. They dislike dark places, and are easily kept away by smoke—a fact that cattle and horses very soon learn to avail themselves of. Animals when attacked by a large number are driven frantic, and will seek to evade their tormentors by rolling in the dust, rushing about, etc. They will at times be almost literally covered by the flies, and in every case the ears are filled clear down to the tympanum, and so thickly that they seem piled upon each other. An inflammatory fever with a high pulse soon sets in, and the animal dies of cramps or convulsions, when the skin of the entire body will be found to be covered with numerous small ulcers. A singular habit was noticed in these insects. On one occasion (March 21) I observed a large, pear-shaped mass of the flies hanging from a blackberry bush, measuring six inches in width and seven



FIG. 514. — Larva of *Simulium*, black fly, enlarged.

in length; after a considerable beating they flew away. Several other instances are known even in quantities much larger than this; in one a swarm attached itself to the handle of an iron pot."

S. molestum is the species most common in northern New England, and one that causes much annoyance to man and beast in the mountainous regions. They have a black body, with transparent wings, and are hence called "black-flies." A southern species resembling them, but smaller, is very annoying to fowls, especially turkeys, whence they are called "turkey gnats." They attack the turkeys in the bare regions about the head, in the ears, eyes, etc., often destroying them in numbers.



FIG. 515. — *Simulium molestum*, black fly, enlarged.

In the BIBIONIDÆ, which includes about three hundred described species, there are three ocelli, there is no transverse suture to the thorax, and the prothorax is much developed. The wings are without a discal cell, and the coxæ are not prolonged.

The larvæ are cylindrical, footless, with transverse rows of bristles, the head often with eyes. They feed on excremental or vegetable substances, especially on the roots of grass, whole patches of which they are said to destroy. The pupæ are inactive, mostly free, remaining in excavated, smooth, oval cavities near the surface of the ground, which the larvæ have prepared before undergoing their metamorphosis, and where the pupæ remain till they are ready to emerge in the perfect state. The males, which are fewer in number than the females, make their appearance several days before their mates; in some species the males differ markedly in coloration from the females, so that they might be considered as different.

The adult flies are most usually seen in early spring about gardens, on flowers, etc. *Bibio albipennis*, our most common species, is black with white wings, and, with other species of the same genus, shows a conspicuous, stout spur on the front tibiæ. They are found in abundance on willows in early spring, but there is also another brood later in the season. Several other species of this genus that are commonly observed are of a deep red color with black wings. The males will be distinguished by their very large eyes, comprising nearly the whole head, and thickly covered with hair. Most of the species are dull and sluggish, and fly heavily.

The family CHIRONOMIDÆ comprises a large number of very delicate flies which, owing to their delicacy and simplicity of structure, have not been much studied by entomologists. Not more than eight hundred species are known. They have no ocelli, the thorax has no transverse suture, the costal vein ends near the tip of the wing, and does not continue around the posterior part; this last character will distinguish them from the mosquitoes, which they much resemble. The antennæ are very strongly plumose, especially in the males, where they form two dense brushes; in the female they are usually shorter, less densely plumose, and composed of fewer joints. The larvæ are soft-skinned, worm-like, often blood-red in color, and usually aquatic, as are also the active pupæ, though some live in decomposing vegetable matter or in the earth. But few of the adult flies can bite like the mosquito, and most of them are harmless or beneficial. Every one has noticed them in abundance in early spring before the snow is off the ground. They will collect in large swarms, dancing in the air. Indeed, over meadows in the Rocky Mountains the writer has seen them rise up at nightfall in the most incredible num-



FIG. 516. — Pupa and anal foot of *Chironomus*.

bers, producing a buzzing or humming noise like that of a distant waterfall, and audible for a considerable distance. While at rest they usually raise their fore legs in the air, and keep them in constant vibration. *Chironomus oceanus* was observed by Dr. Packard in multitudes living on floating sea-weed and eel-grass in Salem Harbor. According to Professor S. I. Smith, the larvæ of numerous species are not uncommon in dredgings from very great depths in Lake Superior, reaching nearly one thousand feet below the surface. Aquatic larvæ may be frequently met with in standing water, often extremely delicate little creatures, sometimes so very transparent as to be hardly distinguishable from the water in which they live.

The species of *Ceratopogon* are usually not aquatic. Some are very minute, and when able to bite are often very troublesome. An extremely small species, called by fishermen midges, is common in the White Mountains and neighboring regions, and together with the black fly, has called forth many an imprecation from the luckless tourist.

It will be hardly necessary to describe the family of CULICIDÆ, or Mosquitoes, as they are familiar enough to all. They will be at once distinguished from all others with long antennæ by the presence of an elongate proboscis, slender and firm; the wings lack the vein on the posterior border, which is delicately fringed with hair; in many the whole surface of the wings is hairy. About one hundred and fifty species have been described.

The name mosquito is the Spanish and Portuguese diminutive of *mosca*, a fly, and has been often applied to the Simuliidæ, but in general only species of this family are known under this term.

Almost every one has noticed in pools or cisterns of standing-water a delicate little creature actively moving about with a jerking motion, and in many localities known under the name of 'wigglers.' They are mosquito larvæ, and feed upon decaying matter, voracious little scavengers of what would otherwise often be miasmatic substances. The eggs are deposited by the female, with the aid of her hind feet, in delicate little boat-shaped masses upon the surface of the water. They are packed side by side with the smaller end uppermost, forming a gently concave mass that readily floats about. They hatch in a few days, when the larvæ escape from the lower end into the water; here they grow rapidly, at times moving quickly about, at other times resting quietly near the surface, and breathing through the stigmatic tube at the tail. This tube has at its end a fringe of hairs, which serve to close the opening when under water, and to suspend the larva from the surface when breathing. The larvæ in species of *Culex* swim with the head downward, while those of *Corethra* and *Anopheles* move about with the head horizontal.



FIG. 517. — *Chironomus oceanus*, male, head of female beneath, enlarged.

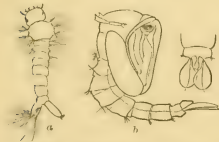


FIG. 518. — Transformations of *Culex pipiens*, a, larva; b, pupa.

The head is fully differentiated, and usually has eyes; the jaws are thickly ciliated, or fringed with hairs, by the means of which a current of water is produced that brings little particles of food within the reach of the mouth.

After changing their skin two or three times they assume a more club-shaped appearance, in which the parts of the adult insect are indistinctly seen. The abdomen terminates in two leaf-like appendages that act as propellers; but in general these pupæ remain near the surface, except when disturbed, and take no food. The breathing organs are no longer a tube at the tip, but there are now two that spring from the sides of the thoracic segments. Finally, when the perfect mosquito is ready to emerge from the pupa, the back of the skin, which has now come to the surface and is exposed, splits, and the fly carefully and gradually extricates itself from the membrane which thus serves the place of a raft till the future legs and wings are sufficiently firm. But right now is the period of the mosquito's life most fraught with danger; a wavelet, a breath of air, or a raindrop hopelessly shipwrecks the frail bark. This is why running waters are free from these insects.

Hitherto only aquatic larvæ are known in this family, yet it seems probable that some species must undergo their transformations in the earth. On the high, dry plains east of the Rocky Mountains they are, during many years, extremely abundant, often many miles from the nearest water or moist ground, and in a region where standing water is almost unknown.

The adult insect is found nearly everywhere, in some places in almost incredible numbers, forming swarms in visible clouds. Instances are recorded in some localities not only of loss of life among cattle and horses, but also of human beings, from their bites. One can understand why there should be so many, for there are several broods during a season, the female laying in all about three hundred eggs. Were all the conditions perfect a single female might produce, at the end of four months, many millions of progeny. When the weather is no longer favorable, the female retires to some sheltered spot and remains during the winter, but even in New England these insects may be seen every month in the year.

The family TIPULIDÆ comprises the largest of the flies with long antennæ, some of them more than two inches in length. The legs are very elongate, and very delicate, so delicate indeed that one seldom succeeds in capturing them without the loss of one or more. They will at once be distinguished from all the allied families by the presence of a complete V-shaped suture on the dorsum of the thorax; at the same time the wings will be found to contain numerous veins and a perfect discal cell. These alone will suffice to recognize species belonging here. The female differs, moreover, from all other nematocerous flies, in having



FIG. 519. — Wing of *Protoplasma jitchii*.

nearly always the ovipositor composed of two pairs of long, horny, pointed valves; these are for the purpose, so rare among Diptera, of depositing the eggs within the ground, or other firm substances. This they do by standing nearly upright, and thrusting the ovipositor downward leave one or two eggs, then, moving a little forward, this operation is repeated till all are laid. When the weather is favorable the eggs hatch out in little more than a week. The larvæ are ash-gray in color, usually more or less transparent, of twelve segments; the head is incompletely differentiated and retractile, and has the maxillæ and mandibles more or less horny and stout; there are short, fleshy antennæ. The organs of loco-

tion generally consist of transverse swellings on the under side which are provided with very minute bristles. The terminal end of the body is truncate, and the single pair of spiracles are situated here, in which character these larvæ differ from those of allied families. On the borders of this truncation there are four or five retractile fleshy processes.

Most of the larvæ live in the earth, or in soil-like, decomposing wood; some, however, live in water, and are soft and slimy, of a dirty, greenish color, and clothed with short, appressed, microscopic hairs. Still others live on leaves of plants, almost like a caterpillar in appearance, in some the resemblance still more heightened by being green in color and provided with a crest of tubercles along the back.

The pupæ, like most of those in this sub-order, are free. The thorax has two stigmatic tubes, and one of them, as in *Psychoptera*, may acquire a very great length for the purpose of breathing under water. The abdominal segments of the pupæ have transverse rows of hairs, bristles, or spines, which enable them to extricate themselves when about to complete their metamorphoses.

The adult flies are not often seen early in the season, but more commonly in the late summer and autumn. They will be most usually met with in meadow lands and forests, flying awkwardly for a few steps close to the ground till they become entangled in the grass or twigs, and then, extricating themselves, rise again to repeat the same aimless, clumsy flight. A singular species, *Bittacomorpha claripes*, found throughout North and South America, is seen both in early spring and late in the autumn, and will strike the observer as ludicrous in appearance. The legs are very elongate, variegated in color and thickly clubbed at their tips. They fly very slowly, with their legs extended, and one is lucky if in attempting to capture a specimen, he succeeds without the loss of half of them. One cannot readily understand why the legs are so delicately attached in this and the allied families. It is probably to enable the fly to escape the entanglements that these apparently useless members are constantly subjecting them to, thereby often saving their lives, at least long enough to reproduce their young. That the loss of several legs does not seriously affect them is evident from the fact that a mosquito will continue pertinaciously to seek its food when one, two, or even three are missing!

Very noticeable species are several of *Trichocera*, so small and delicate that singly they would hardly attract our attention, but they collect in large numbers, forming a small cloud that may often be seen dancing up and down at twilight, in late autumn and early spring, as well as on the more pleasant days throughout the winter.

The name of 'Daddy-long-legs' is the one most usually applied to members of this family in England, but in America this term is commonly used to designate the Phalangidæ or harvest spiders. The English name of 'Crane-flies' is preferable. Commonly they are harmless, but some of the species in the larval state are very destruc-

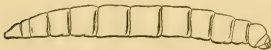


FIG. 521.—Larva of *Chionea*.



FIG. 520.—*Chionea vulga*.

tive, feeding upon the tender rootlets of grass and grain, and causing the plants over large surfaces to wither and die. There are twelve hundred species known.

In this family are placed several wingless forms, or those with the wings more or less rudimentary. One of the former is *Chionea*, the species of which are found on snow, the larvæ living in vegetable matter.

The flies—a misnomer here—have rather short and stout legs, and are less than a half-inch in length.

SECTION II.—BRACHYCERA.

This term is here used in the modified sense proposed by Brauer, to include only those families that belong to the Orthorhapha. In the adult stage, as before said, the division is not a sharp one; it may be characterized by the antennæ, consisting primarily of three joints, the third one often annulate, or simple, with a style or bristle, never with verticillate fringes of hair.

The two following families are frequently spoken of as the NOTACANTHA; they agree in having the scutellum usually with spines or tubercles on its border, the third joint of the antennæ annulate, and the tarsi with three pulvilli.

In the XYLOPHAGIDÆ the costal vein encompasses the whole wing, and the tibiæ are spurred. The larvæ of this small family, so far as are known, live in wood. *Cænomyia ferruginea*, found in shady woods and about old trees, is the most common species that we have. It is about three quarters of an inch in length, and of a deep ferruginous or darker color. Species of *Xylophagus* are remarkable for their general resemblance to certain hymenopterous insects. The family includes about sixty known species.

In the STRATIOMYIDÆ, on the other hand, the costal vein reaches only to the middle of the wing, and the tibiæ are not provided with spurs. The larvæ live in water, earth, or decaying wood. Those of a species of *Stratiomyia* are known to inhabit some of the western alkaline lakes, and a European species is found in salt water. The transformations of *S. chameleon* in Europe are well known. The eggs are deposited by the female, in layers overlapping each other, on the under side of leaves of aquatic plants. The larvæ are naked, smooth, broader in front, where there is a small head; the sides of the abdominal segments are provided with hook-like foot processes. The last three are much narrowed and elongate, the terminal one especially so, and at its



FIG. 522.—*Stratiomyia chameleon*.

tip with a circlet of hairs surrounding the stigmata. When they breathe, these hairs enable the larvæ to keep themselves at the surface, and by their means, when folded, they can retain a small bubble of air and carry it with them beneath the surface. Their food consists of very small aquatic organisms. They swim about in vertical, undulatory motions. The pupæ are enclosed in the anterior end of the larval skin, which enables them to float about freely in the water. They escape at maturity through a slit in the back which has become exposed to the air.

Other species lay their eggs on the surface of the water. The larvæ of *Ephippium thoracicum* are found in nests of *Formica fuliginosa*, those of *Chrysomyia polita* attack the common rape plants; both are European. Species of *Beris* are found in moss, and *Sabula* and other genera in decaying wood. There are nearly nine hundred species known.

The next two families belong to a group called TANYSTOMA, in which the three basal cells are much prolonged, the third longitudinal vein is furcate, and there are five posterior cells; the marginal vein encompasses the whole wing; there are three pulvilli.

The TABANIDÆ have the third joint of the antennæ annulate, and never with a distinct style or bristle. The proboscis of these flies, horse and cattle, or breeze flies,

as they are called, are wholly adapted in the female for piercing. The male, as in the other blood-sucking flies, is a harmless fellow, and spends his time in meadows, on the barks of trees sucking up the sweetened sap, or on flowers seeking honey. The female every one has noticed flying about with a distinct humming tone; the larger species will be observed to follow cattle or horses, repeatedly seeking to find a place upon the animal's back where she will not be molested. Their power of flight is great; often they will be seen to poise in the air perfectly motionless, then in a flash darting away; the fastest speed of a horse will not elude them. Their bites, though painful enough, do not appear so irritating as those of the mosquitoes and Simuliidae. The large puncture they make will often allow the blood to flow after they have withdrawn the proboscis, but apparently they do not leave any saliva in the wound. Blood, however, is not their only food; when nothing better offers, they will, like their males, seek the juices of plants and trees.



FIG. 523.—Mouth-parts of horse fly.



FIG. 524.—*Tabanus borinus*.

The male's eyes are contiguous on the top of the head, indeed the large head in both sexes is chiefly composed of the eyes, which often have most brilliant iridescent markings upon them. That they can see for a long distance seems certain. On the uninhabited plains east of the Rocky Mountains, the writer has frequently seen them coming from a long distance, attracted by the sight of the horse upon which he rode.

Over thirteen hundred species are known throughout the world, and nearly one hundred and fifty in North America. Many are among the largest and most powerful of Diptera, but the largest number are of moderate size, though none are small. Most of them love the bright sunshine, though many seek shady places near the borders of woods, appearing during bright, sunshiny days.

The spindle-shaped brown or black eggs are found in spherical or flat groups, stuck together, and attached to the leaves or stems of grass and other plants; those of the aquatic larvæ are fastened to rushes. The larvæ are carnivorous; many live in the earth, others in water. They are predaceous, often upon snails and injurious insects, thus in a measure repaying the agriculturist for the molestation they cause him. The young larvæ are known to penetrate beetle or other larvæ and remain within them till they have completely consumed them, and their enlarged bodies have filled out the skins. Thus the larvæ of *Hamatopota* have been observed feeding upon *Helops*, and those of *Tabanus* upon *Noctue*.

Theriopterus cinctus is a large species that may often be seen in New England; it is black in color, with a broad, orange-colored band at the base of the abdomen. A more common species occurring throughout all the Eastern states is *Tabanus atratus*; it is deep black throughout, but with a whitish pruinose dust, especially on the abdomen. *Tabanus lineola* is also very common, but smaller; it is so called from the presence of a whitish line on the abdomen.

The family LEPTIDE will be readily distinguished from the Tabanidae by the simple, not annulate, third joint of the antennæ, which is provided with a simple or thickened styliform bristle. Very differently, however, from that family, the species in this, except in the single genus *Symphoromyia*, are wholly unable to bite or draw blood. The family comprises two hundred known species throughout

the world. They are usually of moderate size, and sluggish in their habits, being easily caught; the larger species are commonly found in meadow or woodlands, resting upon stems or trunks of trees, with their heads downwards. They are sometimes predaceous upon other insects.

The larvæ are cylindrical, with or without fleshy abdominal legs, sometimes bristly; the last segment has a transverse cleft, the upper portion of which is provided with two, often backward-bent processes. The pupæ are free as usual; are not provided with spiny tubercles on their front end, and the posterior end has two points below and four above. The abdominal segments have above, or entirely around, a row of bristles. The larvæ are predaceous, living either in the earth, in decaying wood, or in the passages made by beetles; others live in moss, in dry sand, or in water. The eggs of *Atheric* are deposited in large pear-shaped masses attached to dried branches overhanging water. Not only do numerous females contribute to the formation of these clusters, but they remain there themselves and die; the newly hatched larvæ escape into the water. The adults of the genus *Vermilio* deposit their eggs in the sand, and the larvæ form conical pitfalls in which to ensnare small insects in the manner that the ant-lion does. The tenth segment bears above at its tip a transverse row of long hooklets directed backward, but with the hooks bent forward; the eleventh segment has a similar row directed forward, the hooks of which are bent backward. On the fifth segment below there is a single unpaired grasping foot which is capable of being protruded forward and downward; at its tip there are two triangular, sharp, flat chitinous spots, and below them some stiff bristles. The hooklets serve as aids in boring in the sand and to fix themselves; the organ on the fifth segment enables the larva to seize and hold the prey; so securely, indeed, are such insects as ants grasped behind their necks, that they cannot bite! This last organ also serves, through a lateral motion of the front end of the body, to cast out a quantity of sand in the process of forming their conical pitfalls.

The family MIDASIDÆ, though a small one, including but one hundred known species, is composed chiefly of large, often very large, flies. They will be recognized best by their antennæ, which are elongated and clavate at their tip, the third joint composed of several distinct segments; the veins of the wings are complicated and variable. The earlier stages are known in but two or three species. The larvæ of *Midas fulripes* are known to live in decaying sycamore trees and are probably carnivorous in their habits. They are from one and a half to nearly two inches in length, cylindrical, and with swellings below the abdominal segments for locomotion. The pupa of *M. clavatus* has at its anterior end, eight strong, sharp hooklets. The hind edges of the abdominal segments are provided with a circlet of flat, three-cornered thorns which are directed backward. On the tip of the last segment there is a pair of strong claw-like hooks bent downward. The fly is of a deep black color with an orange-colored band across the base of the abdomen above; they are found about old stumps and logs in the latter part of June and July. Other species are said to be predaceous in the larval state upon *Prionus* and other beetles.

The ASILIDÆ or Robber-flies, as the Germans call them, comprise a large family scattered over the world and numbering about twenty-five hundred known species. They are mostly large, some very large, one species from the West measuring two inches in length. The three basal cells of the wing are much prolonged; the third longitudinal vein is furcate, and there are five posterior cells. The third joint of the antennæ is simple, and the under lip is horny; there are also two fleshy pulvilli on

the tarsi. They are the most predaceous of all flies, and indeed, one might almost say of all insects. The greater part of them rest upon the ground, and fly up when disturbed, with a quick, buzzing sound only to alight again a short distance ahead. All their food, which consists wholly of other insects, is caught upon the wing; their luckless victims when once caught in their stout, strong feet, are powerless to escape. They are not particular in their choice; any insect flying by them is at once pounced upon as by a hawk. Other flies and Hymenoptera are usually their food, but flying beetles, especially the Cicindelidæ, are often caught, and they have even been known to seize and carry off large dragon flies. Not only will they feed upon other Asilidæ, but the female frequently resents the caresses of her mate by eating him up, especially if he is foolish enough to put himself in her power. In an instance that the writer observed, a female seized a pair of her own species, and thrusting her proboscis into the thorax of the male, carried them both off together. *Promachus fitchii* has been known to destroy as many as one hundred and forty-one honey-bees in a single day. Some species of *Laphria* resemble the humblebees remarkably.



FIG. 525.—*Euxer bustardii*, robber fly.

The larvæ are cylindrical or depressed, with parchment-like skin, without legs, or with only slight abdominal protuberances. The larvæ live chiefly under ground or in rotten wood, especially in places infested with grubs of beetles, upon which they will feed. The young larvæ will bore their way completely within beetle larvæ and remain enclosed until they have consumed them. Many, however, are found where they evidently feed upon rootlets or other vegetable substances. They undergo their transformations in the ground; the pupæ have the head provided with tubercles, and on the abdominal segments there are also spiny protuberances and transverse rows of bristles, which aid the insects to reach the surface when they are ready to escape as flies.



FIG. 526.—Pupa of *Proctacanthus*, robber fly.

The small family NEMISTRINIDÆ includes but little more than one hundred known species, of which Europe and North America have scarcely a dozen. Many of them have the wing with numerous cross veins, almost reticulate in appearance, and a large part have the proboscis elongate, sometimes remarkably so; *Megistorhynchus longirostris*, from Africa, although only about two-thirds of an inch in length, has a proboscis nearly three inches long, which it employs in sucking the nectar from the long-tubed flowers of gladioli, etc.

The transformation of but a single species is known, recently discovered by Handlirsch, in the only common European one, *Hirnanura obscura*. He observed the female fly depositing her eggs deeply within the burrows of *Anthasia*, a small wood-boring insect, in the pine rails of a fence. The eggs were found in clusters, and the young larvæ hatched from them differed very singularly from the larvæ of a more mature growth. They were more slender, and had a somewhat different arrangement of the mouth parts, but they were distinguished principally by the sixth to the twelfth abdominal segments each being provided with a pair of false legs, bearing a single elongate hooked seta at their tips, the hooks pointing backward; while on the thirteenth segment there were two pairs of similar setæ, the hooks of which, however, pointed forward, thus enabling the larvæ to attach themselves firmly, and to raise themselves

erect. These young larvæ issued in large numbers from the burrows in which they were hatched, and, placing themselves in an upright position at the entrance, allowed themselves to be blown away by the wind. Here for a time they have not been followed, but it is probable that they attach themselves by the aid of their ventral hooks to the bodies of large-sized beetles, the *Rhizotrogus solstitialis*, by which they are carried into the ground when the female enters to deposit her eggs. This is probable from the fact that hundreds of pupæ and pupa skins were observed near the fence, protruding from the ground, and kept upright by means of their terminal hooklets. On searching below these, in every instance the remains of the larval skins were found at the depth of about two inches, and still deeper, were found the remains of the above-mentioned beetles, and in one instance the mature larvæ were seen issuing from the abdomen of the beetle.

In the United States only three species of this family are known, a *Hirmonneura* and two *Rhynchocephali*, the latter interesting from the fact that the two other known species of the genus, both very closely allied to ours, are inhabitants of the region about the Black Sea only.

The BOMBYLIIDÆ will be recognized by their having the three basal cells much prolonged, with usually four posterior cells, and the third joint of the antennæ not annulate. The family is a large one, comprising about fourteen hundred known species, and exceedingly rich in varied forms, scattered over all parts of the world. They are usually clothed with long and delicate hairs, and with the wings often with dark markings. Most of them are very swift-flying insects, often hovering motionless in the air for a time and then darting away with the rapidity of the wind. They seek sunny places in woodland roads, about blossoms, or on rank vegetation. *Bombylius fratellus* appears in New England often in March long before other insects have become at all abundant. In general the members of this family are prettily marked, and in their life histories are often very interesting. In the adult state they are flower-flies, feeding



FIG. 527. — *Bombylius fratellus*.

upon the pollen and honey which they extract by the aid of the proboscis, which is often very long.

Bombylius medius, an English species, lays its eggs near the entrance of the holes of a large species of *Andrena*, whose larvæ and pupæ are devoured by the fly. Another species is parasitic upon *Colius*. *B. major*, a European species which also occurs in the Pacific States, is also found in the subterranean nests of *Andrena*. Other larvæ of this family are parasitic upon species of *Megachile*, *Cremomus*, *Calicodoma*, *Limacodes*, *Odynerus*, *Trypoxylon*, etc.

Among the most interesting, biologically, and at the same time exceedingly useful insects are *Triodites* and *Systechus*, a number of species of which occur from the central to the Pacific States. Their larvæ are found in the egg-pods of the locust *Caloptenus spretus*, so destructive throughout the West. "These larvæ begin to transform themselves into the pupa state early in the summer, and the pupa pushes itself half way out of the ground in order to disclose the fly. These continue to issue during the summer months. As a rule but one year is required for full development. *Triodites* is first observed as a large, yellowish-white grub, about a half an inch long when extended, it being usually curved so that the head and tail nearly meet. It is usually found in a case of locust eggs which it has devoured, pushing the empty shells aside, and at last occupying the space where were twenty-one to thirty-six eggs. Often

it is found in a little space below a number of empty cases as though it had feasted off the contents of several nests" (Riley). *Callostoma fuscipennis* has been observed to feed upon the egg-sacs of *Caloptenus italicus* in the Dardanelles.

Species of *Anthrax* often have the wings in large part dark brown, and will be observed flying about on the sandy ground, and resting on sticks, leaves, stones, etc.



FIG. 528.—*Anthrax samitro*, with pupa.

The species of the small family **THEREVIDÆ**— numbering about two hundred known forms— will be distinguished from the *Asilidæ* by their having the under lip not horny but fleshy. The short antennæ have a terminal style of variable form, sometimes wanting. The larvæ are very slender, snake-like in form, showing apparently nineteen segments beside the head, which is due to a seeming division of the anterior ones. Their antennæ are very small and short. They live in the earth and decaying wood, either carnivorous or feeding upon vegetable substances. The larvæ of a European species is said to be parasitic upon the pupæ of *Alencis* and *Sphinxæ*. The pupæ in front have spines as in the *Asilidæ*. Most of the flies are of moderate size, and, although carnivorous, are far less active than the *Asilidæ*. The legs are less stout, and in many are easily broken off when captured. Their food is chiefly other *Diptera*, for which they lie in wait upon leaves and bushes, and sometimes on the ground.



FIG. 529.—*Scenopinus fenestralis*, a, larvæ; carpet worm, enlarged.

Scenopinus fenestralis, which belongs to a distinct family, the **SCENOPINIDÆ**, may be noticed here. It will be recognized by the accompanying figure. It is common to both Europe and America, and derives its specific name from its prevalence at times on the windows of dwellings. The very slender larvæ are not infrequently found under carpets and in furniture,

but, so far from being injurious, they evidently feed upon the destructive *Psocidæ* and *Tineidæ*.

The **ACRO CERIDÆ** or **CYRTIDÆ** are a small family of curious flies, often remarkable for their small, one might almost say minute, head, composed chiefly of the eyes. The thorax and abdomen are much inflated, the tegulæ are exceedingly large and arched, the terminal joint of the antennæ is simple, the tibiæ are without spurs, and there are three pulvilli. The wings are very variable in neuration, sometimes simple, sometimes intricate. The larvæ are apparently chiefly parasitic, and in the few species in which they have been observed are parasitic on spiders or their cocoons, in the former cases the young larvæ living within the abdomen. Several species of the genus *Eulonchus* are found in the Western States, rather more than half an inch in length, and with a yet longer proboscis, with which they are enabled to feed upon the juices of flowers. These species are of a brilliant steel-blue color, but usually they are smaller, obscurely colored, with



FIG. 530.—*Lasia electa*, enlarged.

short probosces or none, taking no nourishment in the adult state. They are generally slow and feeble in their movements. The eggs, which are black in color and numerous, are deposited upon the dried twigs of trees. *Lusia klettii* from Arizona is of a metallic green color with golden reflections, and the proboscis is one-half longer than the body.

The family EMPIDÆ is a large one, but chiefly occurring in cold or temperate regions. About eleven hundred species are known. They resemble the Asilidæ very much in their habits as well as in their form, though they generally are small in size. The head is spherical, the eyes contiguous above in the males; the head above is not excavated, the third joint of the antennæ is simple, with a terminal style, or a terminal or dorsal bristle. The basal cells are elongate, the third vein sometimes furecate, and there are three or four posterior cells.

The larvæ are cylindrical, with small swellings for locomotion on the under side of the mesothoracic segments. They are probably carnivorous, and live in the earth, under leaves, or in decaying vegetable matter. The pupæ are free, with two prorect points at the anterior end.

Many of the species are observed in the early spring, dancing in large swarms over streams of running water. They are exceedingly voracious in their habits, feeding chiefly upon other flies. Many run about with great swiftness, reminding one of the following family, which they also in their early forms strongly resemble. As in the Asilidæ they make much use of their front legs in capturing and holding their prey; in consequence we find many structural peculiarities in these members, as also is the case with the Dolichopodidæ. Such may consist in thickening of the joints, in elongation, in peculiar discs of hair, or in being bent; in some they are peculiarly prehensile organs, the coxæ being very long, and the femora being thickened and armed with spines beneath. Many pursue their prey on foot, and will carry about with them insects even larger than themselves, impaled upon their murderous probosces. As is the case among the Asilidæ, the female not only resents the advances of the male, but, should he be so luckless as to place himself within her power, she would despatch him without compunction; hence it is that the male seizes the opportunity to make his advances when she is too busily engaged feasting upon some insect to be able to devour him.

The family DOLICHOPODIDÆ includes a very large number of small, usually brilliant blue or green, active and predaceous flies, nearly all of which are beneficial to the agriculturist. They may be distinguished by the first basal cell being short, the second united with the discal cell, the third small. The third longitudinal vein is not forked, and there are three posterior cells. The hypopygium of the male is large and bent under the abdomen, and is complicated in structure. The antennæ are simple, of three joints, with a terminal or dorsal bristle.

The larvæ are long, slender, and cylindrical, and live in the earth or in decomposing vegetable matter. The pupæ are free, or form cocoons; their anterior stigmata in the thoracic region are two elongated horny tubes. The flies have delicate, slender legs, running about forwards, backwards, and sideways with great activity on the leaves of plants. Most of them capture small Diptera or other insects, to even worms, with soft bodies, and suck out their juices. They are usually found in damp places covered with a rich vegetation; many are principally found on the leaves of aquatic plants, on stones partly overflowed with water, on dams, and near waterfalls; some of them are able to run rapidly over water, even when it is rippled by the wind; others are

fond of salt or brackish water; still others prefer dry situations, and are found on stumps of trees, fences, etc., even in very dry and hot weather" (*Loew*). The proboscis is short, and not so well adapted for piercing hard insects as in the Asilidae and Empidæ. As in the latter family, the legs often present ornamental and structural characters, many of which may serve for grasping and holding their prey. About twelve hundred species are known throughout the world.

SUB-ORDER II.—CYCLORHAPHA.

Larvæ without a differentiated head, the first segment never chitinous, with soft, wart-like antennæ, or wholly without appendage, showing only a mouth opening. Body cylindrical or flattened, smooth, or with swellings for locomotion, or with girdles of short bristles, sometimes with thread-like filaments. The larvæ shed their skins twice or thrice before assuming the pupal stage, escaping through a rent at the posterior end. Pupæ always enclosed in the contracted larval skin, the adult insect escaping through a circular orifice at the anterior end. Adult insects with an arcuated impressed line, immediately above the antennæ, separating a small crescentic piece, the frontal lunule.

Brauer accepts two sections in this sub-order, viz., *Aschiza*, with the families of Syrphidae, Platypezidae, Phoridae, and Pipunculidae, and *Schizophora* with all the other families.

The SYRPHIDÆ may be at once distinguished with certainty in nearly every case by a peculiarity of venuration. Between the third and fourth longitudinal veins, and nearly parallel with them, there is a spurious or false vein, of greater or less extent and distinctness. The antennæ in nearly all have a bristle on the upper border of the third and last joint; in a few there is a terminal style. The eyes are usually contiguous above in the male, and they are sometimes provided with enlarged facets in this sex; sometimes in both they are prettily ornamented with colored markings. In coloration the flies are generally very conspicuous, and often strikingly handsome; consisting of bright yellow spots and bands on black or green, often metallic ground.

In size they are seldom very large or small; but in shape they present the utmost diversity. In *Volucella crecta*, a species not uncommon throughout the United States, the body is nearly the size of a humble-bee, and very much like some of them in appearance. It is thickly clothed with long black and yellow pile, the antennæ are elongate, and the bristle of the third joint is very thickly plumose feathery-like. Most curiously too, European species, distinguishable with difficulty from this, are parasitic in the larval state upon the young of humble-bees. The larva of *V. bombylans* has along each side two rows of short spines, with six longer ones radiating from the thickened and rounded posterior end. Undoubtedly the larva of *V. crecta* will be found to be similar, and with similar habits.

A very interesting species is *Eristalis tenax*, probably first an European species, but which has become now almost cosmopolitan. It is rather larger than a honey-bee, which it resembles so much that few persons not acquainted with it would care to touch it. Like all the members of this family, it lives upon the juices of flowers, especially sweet-smelling ones such as Hymenoptera prefer, but it most commonly attracts our attention by its appearance in houses on windows late in the autumn. Although so conspicuous an insect, the earliest record we have of it in America dates no further back than 1870; at present it is common from the Atlantic to the

Pacific. The larvæ, as in *Mallota* and some other species of the family, are very curious creatures. They are ovate in shape, somewhat elongate, with seven pairs of abdominal legs below, each of which terminates in a hooklet; posteriorly they end in a long, slender tail, composed of two joints, the last of which slides within the preceding one like the joints of a telescope. This curious organ enables them to breathe from the surface while lying snugly concealed in mud or in outhouses, where they feed upon decaying vegetable or excrementitious matters. This peculiarity of structure has given them the name of "rat-tailed larvæ." Their skins are very tough, whence comes the designation of *tenax*. The pupal envelope of the rat-tailed larvæ is ellipsoidal in shape, with the tail bent over the body.



FIG. 531. — Larva pupigera of *Eristalis*.

Interesting also are the habits of members of the genus *Syrphus*, of which there are about twenty-five North American species. The flies are usually less than a half inch in length, very prettily banded with yellow, and, like many others of the family, are remarkable for their rapid motions in the air, and the ease with which they hover over flowers. The larvæ are cylindrical maggots, without a head, and the mouth-parts consisting of from two to four outwardly-bent hooklets. The eggs are deposited by the female upon plants infested by plant-lice. The young larvæ as soon as hatched crawl over the stems and leaves till they come in contact with the Aphides, which they pierce with the hooklets and, holding aloft, suck out their juices, to the number of a hundred or more daily. When ready to undergo their transformations they attach themselves to the leaves, and the larval skin contracting forms an oval puparium or larva pupigera.



FIG. 532. — *Syrphus mesograpta politus*, enlarged.

Another interesting group in their early forms are the species of *Microdon*. The flies are usually dull colored, rather slow in flight, and found on borders of low woodlands. They can generally be recognized by the presence of a pair of spines on the scutellum, and by their antennæ being elongated. The larvæ show a strange resemblance to certain shells, so much indeed that



FIG. 533. — *Microdon globosus*: a, larva just before pupation; b, front view of pupa case; c, larva pupigera.

twice have they been described and named as species of molluscs!

The larvæ of *Baccha*, *Spherophoria*, *Pipiza*, and *Paragus* are also known to feed upon plant-lice. The larvæ of many species live in decaying wood, in the stems and bulbs of plants, under bark, in water, and about ants' nests, all of which are characterized by the stigmata being confined to a single or double breathing-tube of variable length at the hind end of the body.

Mallota posticata, here figured, is black, thickly covered with black and yellow pile; the larvæ and pupæ are found in old trees. *Pipiza radicum* is a small fly of a uniform dark metallic color; its larva lives underground, and feeds upon the apple-root lice (*Eriosoma pyri*) and the grape-root lice (*Phylloxera radicola*).



FIG. 534. — *Mallota posticata*; a, larva pupigera.

Not a few species resemble Hymenoptera, both wasps and bees, to such an extent that even experienced dipterologists will sometimes hesitate to handle them till they are assured of their harmlessness. Such ones, in a most striking degree, are the species of *Ceria*, which differ from other Syrphidae in having a terminal style to the elongated antennae. Not only are the thorax and abdomen covered with bright yellow markings in the manner of wasps, but the abdomen is also narrowed at the base, almost petiolate. Nineteen hundred species of the family are known throughout the world; in the United States we have two hundred and fifty now known.

The species of *Conops*, the type of the family CONOPIDÆ, are often distinguishable with difficulty, without a close examination, from certain species of *Ceria*, of which we have just spoken; they do not have, however, the false vein in the wing. The hypopygium in this family is also symmetrical and turned under the abdomen, and the eyes in both sexes are equally broadly separated.

They are pretty flies, and are found upon flowers with the *Syrphidae*. The genus *Stylogaster*, composed of four species found in Africa and America, is remarkable for having the female ovipositor longer than the entire body, with the exception of the proboscis, which is yet longer, and provided with two hinges. The larvæ of members of this family are parasitic, chiefly upon humble-bees and wasps, but also they have been found in the bodies of locusts (*Ædipoda*). The writer has observed *Conops tibialis* following a species of *Bombus* and repeatedly flying against it. It is probable that the eggs are thus deposited by the female upon the body of the bee, and, hatching, they burrow within the abdominal cavity, and there remain feeding upon the non-vital portions till they have arrived at the period for their transformation, when they escape in the adult form through an opening made between the abdominal rings. The family is represented so far in the United States by about thirty species.



FIG. 535.—*Conops tibialis*.

There are but few examples among insects that offer such strange and curious facts in their biological history as in the family of ÆSTRIDÆ or Bot-flies. They are mostly flies of moderately large size, more or less hairy, and inconspicuous in their coloration. The antennæ are small, inserted in rounded pits from which only the small bristle projects; the middle part of the face is exceedingly narrow, the opening of the mouth is very small, and the oral parts rudimentary. The tegulæ are very large.

All the species yet known (about sixty) are parasitic in their larval state upon vertebrate animals. The adult fly takes no nourishment, but subsists for a few weeks, long enough for procreation, wholly upon the substances stored up by the larvæ. With a single exception the parasitism is confined to mammals, and occurs in three different ways, the larvæ living under the skin, in the nostrils and frontal sinuses, and in the stomach. It is an interesting fact that with but few exceptions each species is confined to a single animal, and each genus, or rather each group of allied species, is parasitic in the same way upon similar animals.

Seven species of *Gastrophilus* are found in the stomach or the intestines of the horse and ass; other species believed to be of this genus, whose transformations are known, live in the stomach of the elephant and rhinoceros.

Thirteen species of *Hypoderma* are known to live in the skin of the horse, the ox, the buffalo, the sheep, the goat, four species of antelope, and the musk deer. Species of *Æstomyia* likewise infest the skin of *Lagomys* and *Hippobosus*. *Ælomyia tarandi* is parasitic in great numbers in the skin of the reindeer in both Siberia and

North America, and is said to be the cause of the deer rubbing themselves in spring to such an extent as to wear off the darker hair, and thus change their appearance. Species of *Æstrus* live in the frontal and nasal cavities of sheep and various antelopes. *Cephalomyia* lives in the nasal fosse and throat of the camel; *Pharyngomyia* and a number of species of *Cephenomyia* in the fauces of various species of deer. *Rogen-*



FIG. 536.—*Cuterebra buccator*, dorsal and side views.

hofera grandis lives under the skin of a South American mouse (*Hesperomys*). *Cuterebra emasculator* lives in the male organs of species of *Tamias*, and derives its specific name from the effects it produces upon these glands; other species of this

genus occur in the skins of rabbits, gophers, and opossums. Species of *Dermatobia* infest the skins of dogs, cattle, *Felis concolor*, *Cervus rufus*, monkeys, and even man himself.

It will be of interest to trace the habits in detail of some of the more important, for which I am mostly indebted to Brauer, to whom our chief knowledge of this family is due.

The female of the common horse bot-fly, *Gastrophilus equi*, when her eggs are ready for deposition, seeks a horse, or an ass if it be either of the species peculiar to this animal, and, flying slowly about, holds her body nearly upright, with the elongated ovipositor directed downwards and inwards. When she has found the proper place to deposit the egg she remains for a second in this upright position, then flies suddenly away for a short distance, leaving the single egg attached to a hair, with its larger end directed outward. In a few moments another egg is ready and this operation is repeated, always choosing the same part of the body, which is usually on the front and inner side of the knees. They are attached to the hair by means of a fluid substance which quickly dries and holds them firmly. In this way from four to five hundred eggs are laid, and they are by no means placed at haphazard in any place, for their future existence depends upon their being in such situations as the horse can easily reach with his lips. It is a curious instinct which teaches horses that these insects are to be avoided; although the fly can cause little irritation in the process of laying her eggs, yet the horse will twitch the skin each time, and will show the utmost annoyance, often becoming unmanageable.



FIG. 537.—*Gastrophilus equi*, horse bot-fly, and a, larva, enlarged.

In a few days the eggs hatch, leaving the shells still firmly fastened to the hairs, and the young larvae are then conveyed to the mouth of the horse when biting or nipping such parts as are irritated. It is thus the more interesting to observe that the eggs are usually laid on such portions of the body as are most accessible to the animal's mouth, although it is believed that the young larvae may reach the mouth by their own activity. They are swallowed with the food, and, upon entering the stomach, attach themselves to the inner membrane by means of the hooklets that encircle the

mouth. Here, for a period of nine or ten months, they feed upon the substance of the stomach and the suppurative matter produced in the deepened cavities they cause. When only a few are present they cause little apparent injury to the animal, but when they exist in large numbers they may produce sufficient inflammation or loss of blood to cause death. When at last they are ready to undergo their transformation, they loosen themselves from the stomach and are carried through the intestinal canal and ejected with the excrement. The pupal state, which occupies thirty or forty days, is passed in the earth, whither the larvæ have previously entered, or in the excrement with which they fell.

G. hemorrhoidalis, which also infests the horse, deposits its eggs only on the lips and hairs of the lips, thereby causing much annoyance. When a fly makes its appearance the horse will endeavor to evade it by rubbing his nose upon the ground or on the trunks of trees, or he will take refuge in water. The flies will hide themselves in the grass and seize the opportunity to quickly deposit their eggs when the horse is feeding. They have a sharp and peculiar smell which horses seem to recognize, as is evidenced by their actions. The eggs are black, and hence not so easy to distinguish as the light-colored ones of the preceding species. The larvæ differ also in seldom attaching themselves to the membrane of the stomach, but pass on to the small intestines, where they lodge. When nearly ready to pass out they fasten themselves to the external orifice, and loosen themselves and escape at any time.

The eggs of *Hypoderma* are deposited on the hair about the front shoulders, neck, and groins of artiodactyls only. It was thought for a long while that the female thrust the eggs within the skin, but such is now known not to be the case. Hence it is that the great fear that animals show at their approach, and which has often been observed since the *οιςτρος* of Homer, is the more remarkable. Cattle seem especially to fear them. As soon as one makes its appearance in a herd it will cause the most unmistakable signs of anxiety, the cattle running about with their tails erect, bellowing and pawing the earth, and if possible seeking refuge in water. The eggs are of peculiar structure. They are elongate, flattened oval, with a five-sided projection at one end, and the covering is very firm and tough. The larvæ when first hatched are small, slender, and cylindrical, with their mouth-parts adapted for boring their way into the skin. Here they remain concealed till the following season and until they have shed their first larval skin. In the latter part of their larval state, which extends over two or three months, they become much larger, measuring about an inch in length, their skin becomes hard and tough, and it is now necessary to seek an external communication with the air. This they do by means of a small orifice in the large ulcerative sac within which they are enclosed, and through which orifice the stigmata protrude. Here they remain, feeding upon the suppurative matter which they cause, in a quiescent condition, till they are nearly ready to escape. They have the peculiar



FIG. 538. — *Hypoderma bovis*, bot-fly and larva, enlarged.

ability to contract either end into an elongate cylindrical form, which not only serves them in their egress but also to bore into the ground. A few days before they are ready to emerge they begin to enlarge the opening by this expansion and contraction; when they have enlarged it sufficiently, a ring-like contraction of the body, that begins at the posterior part and progresses toward the head, enables them in a few minutes to free themselves, which they usually do in the morning hours. Upon the ground they creep about until they meet some obstruction, when they burrow from one to two inches below the surface, and remains as in *Gastrophilus* species.

As one would suppose, these insects are injurious when they exist in considerable numbers, and as many as one hundred have been observed on a single ox. Another and not inconsiderable damage that they cause is in injuring the skins for leather. The larvæ are commonly called "grubs" by cattle men, and their presence may readily be detected not only by the touch, but also by the sight, so large are the swellings they cause.

A third mode of parasitism, in the frontal and nasal sinuses, is quite as interesting as the two ways just described. For this the common sheep bot-fly, *Æstrus ovis*, may

be taken as an example. The fly is a little less than half an inch in length, nearly bare, yellowish gray, with yellowish white and marbled abdomen. The flies frequent places where sheep are herded, resting on stone walls or on trees, till the female is ready to deposit her young, for in this and some other species with similar habits the eggs are hatched within the oviduct of the parent and extruded alive. With the appearance often of a single fly in a flock of sheep the most intense excitement may prevail.



FIG. 539. — *Æstrus ovis*, sheep bot fly, larva (enlarged), and pupa.

The animals will hold their noses between their legs in close proximity to the dusty waysides, or they will crowd together in hot, barren, open places with their noses in the dust, in their endeavors to evade their tormentors. The flies, with quick motions, eject the young larvæ within the nasal orifice, whence the small, active maggots crawl backward into the passages of the nostrils or throat and usually into the frontal sinuses, where they remain feeding upon the mucous membrane and serum till they have attained their full growth, requiring a period of about nine months. When ready to change into the larvigerous pupæ they dislodge themselves, and either crawl out or are ejected by the animal in coughing. Falling upon the ground they quickly find a sheltered spot in the soft earth or under leaves, and there remain for about six weeks till they are ready to emerge as flies.

When numerous larvæ develop within the nasal and frontal cavities disease and often death ensue. At the beginning they produce a thin discharge from the nostril, which afterwards becomes thick and purulent; at the same time there is a constant sneezing. Later the animal constantly shakes its head, rubs its nose upon the ground, fences, or its own legs. Still later it goes about with sunken head, with a staggering, dizzy gait, with reddened and watery eyes and heavy breathing, which may culminate in death.

Several instances have been reported of larvæ, probably of *Dermatobia*, being found in the human flesh. It is probable that these, or larvæ of *Hypodermat*, when accidentally placed on the skin, bore in, but it is not probable that the fly deposits her eggs on the human body except possibly when deceived by an odor conveyed from cattle or horses.

The very large family of *Muscine* comprises more than a third of all the known flies. The antennæ always consists of three joints, the third of which has a simple or feathered bristle on its upper border; there is no false vein in the wings. They show a considerable variation and are divided into numerous sub-families, which by some entomologists are considered of family rank. In America they have been but little studied, the larger portion being yet without names.

In the *Muscine* the first posterior cell is much narrowed or closed, and the bristle of the antennæ is feathered to the tip. The common house-fly (*Musca domestica*) will readily serve as an example. In this species the larvæ are simple maggots without legs or head, and with two or three hooklets at the mouth. They are more slender in front, smooth, shining, soft, naked, and more or less transparent, and about eight or nine millimeters in length. They are found in almost every kind of decaying vegetable or animal matter, such as offal, manure, dead animals, even spittoons that are filled with tobacco; indeed filth in any form is the home of these disgusting creatures. They crawl readily about by the extension of the terminal part of the abdomen, and easily find their way into the interior of moderately firm substances. The eggs are laid in groups together, about eight days after pairing, and in from twelve to twenty-four hours the young larvæ make their appearance. Each female lays about seventy eggs. In about fourteen days the larvæ attain their full size, when they crawl into some dry or protected place and contract into larvigerous pupæ, in which stage they remain for one or two weeks before appearing as perfect insects. This fly is perhaps the most cosmopolitan in the whole order, being found in almost every part of the world. Their food consists of whatever they can suck up through their fleshy proboscis, or can scrape off with their roughened labelle and dissolve with the saliva.

Another fly as well known as the preceding species, and equally detested by the housewife, is the blow-fly, *Calliphora vomitoria*. It is larger than the house-fly, black in color, with a steel-blue abdomen that shows delicate white, shimmering markings in different reflections. The flies are attracted very readily by the odor of cooking meat and vegetables, and are very noticeable in their loud buzzing and aimless flight against the window-panes. Scarcely any precautions will prevent them from depositing their eggs in fresh or decaying flesh, cheese, or nitrogenous vegetables. Great numbers of the eggs are laid, whether singly or in clusters. They hatch in about twenty-four hours, and the voracious myriads of maggots soon consume the substances in which they live, and then as readily devour each other. They attain their full development in a few days, and then, as in the house-fly, crawl aside into some protected spot and transform into pupæ.

The screw-worm fly (*Comptosia macellaria*) belongs to this group, and is found from Patagonia to Canada. It is a bright metallic green fly, with golden reflections and four black stripes on the upper part of the thorax, measuring about one-third of



FIG. 540. — *Calliphora vomitoria*, enlarged.

an inch. Not content with the ordinary habits of the blow-fly, they will deposit their eggs in wounds of man and other animals, also at the openings of the human face. Several fatal cases have been reported in this country caused by these larvæ, to the number of several hundred, growing within the nasal cavity. In South America cases have been much more numerous.

A very common and wide-spread species is the stable-fly, *Stomoxys calcitrans*. They do not frequent our dwellings as do the house-flies, except before storms and in the autumn, but the annoyance they cause horses and cattle is very great. They resemble the common house-fly very much at first sight, but will be distinguished by their holding the wings more spread apart when at rest, and more especially by the proboscis being slender and firm, and directed forward. It is adapted for piercing, and their food is chiefly the blood of vertebrate animals. The larvæ live in fresh horse manure.

A more famous member of this group, allied to the last, is the Tsetse fly (*Glossina*



FIG. 541. — *Glossina morsitans*, tsetse fly; a, head; b, antenna; enlarged.

morsitans) of Africa, whose bite is so pernicious to horses and cattle as to render the regions which they infest almost impassable for these animals.

The Sarcophaginae differ from the Muscinae in the bristle of the antennæ not being feathered to its extremity. Many of the species resemble each other, and will be recognized by the figure on page 429. The larvæ live in excrements, decaying vegetables and fruits, or in flesh. Not infrequently the larvæ, especially of *Sarcophila*, have been known to infest the ears, nose, and wounds of man and other animals in the manner of *Comptosia*. The female deposits many thousands of eggs, or, what is very frequently the case, living larvæ, the eggs having been hatched before extrusion. Unlike the Muscinae, some few species have been observed as parasites on the early stages of beetles, moths, and grasshoppers.



FIG. 542. — *Tachina doriphora*.

In the entire order, possibly in the entire class of insects, there is no group so beneficial to man as the Tachininae. The species are very numerous, and in North America nearly wholly unnamed. They are usually short, thick-set, bristly flies of small to moderately large size, and will be distinguished from the two preceding families by the bristle of the antennæ being wholly bare. They are sober-colored, rarely conspicuous, quick-flying and abrupt in their movements, and frequent flowers and rank vegetation.

The larvæ are thick, cylindrical, somewhat flattened below, the segments with transverse swellings for locomotion, either naked or with bands of fine, short bristles. Almost all are parasitic, chiefly within the larvæ of Lepidoptera, but also frequently those of Orthoptera, earwigs, beetles, some Hymenoptera, isopod crustaceans, and on turtles.

Of the numerous other sub-families, which are composed chiefly of small flies, only a few can be mentioned here. With the exception of the Anthomyiinae, they will be distinguished from the preceding group — the Muscidae Calyptratae — by the absence or rudimentary condition of the tegulae or membranous scales above the halteres. They have hence been called Muscidae Acalyptratae.

Most of the species live in excrement or decaying vegetable matter, but many are leaf miners, others gall producers, etc.

Very noticeable are many of the Ortalinae and Trypetinae, mostly small species with beautifully marked wings. Many of their larvæ live in fruits, and in the stems of plants, producing galls, others are leaf miners. A common species is *Strauzia longipennis*, a yellow fly with wavy markings on the wings that will be seen about sun-flowers, resting on the leaves with the wings outstretched and in gentle motion. *Camptoneura picta* is another very common species; it has dark brown wings, with a triangular transparent spot in front and another behind.

The larvæ of *Piophilila casei*, or cheese-mites, are known to every one. The fly is shining black, about four millimeters in length, with transparent wings, and the four posterior legs yellowish. "The whitish larva is cylindrical, about a fifth of an inch in length, and is acutely pointed toward the head, and truncated behind, and with two longer fleshy filaments on the lower edge. When moving it extends its mouth-hooks and pulls itself along by them." The power of leaping possessed by them has long been observed, whence they are often called "skippers." "When about to leap, the larva brings the under side of the abdomen towards the head, while lying on the side, and reaching forward with the head, and at the same time extending its mouth-hooks, grapples by means of them with the hinder edge of the truncature, and pulling hard suddenly withdraws them, jerking itself to a distance of four or five inches." (Packard.)



FIG. 543. — *Piophilila casei*, cheese-fly, enlarged.

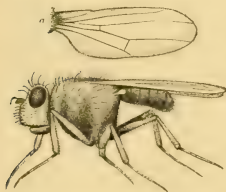


FIG. 544. — *Ephedra halophila*: a, wing, enlarged.

Other species of this genus have the singular habit of living in wine, or even in strong alcohol, in their earlier stages.

Of more especial interest are species of *Ephedra*, remarkable for their habit of living, often in fabulous numbers, in marine or strongly alkaline waters. An account given to the writer by Professor Brewer concerning the habits and uses of *E. californica* is of interest: —

"The waters of Lake Mono are clear, *very* heavy, have a nauseous taste, and, when

still, the lake has a look as of oil and is not easily disturbed. The water feels slippery to the touch, and will wash grease from the hands or from clothes, cold, more readily than common soap-suds will when hot. It is said that no fish or reptile lives in it, but it swarms with countless millions of larvæ, that develop into flies which rest on the surface of the water, as well as cover everything on the immediate shore. The number and quantities of these flies and larvæ are absolutely incredible. They drift up in heaps along the shore, and *hundreds of bushels* could be collected! They only grow at certain seasons of the year, and then Indians come from far and near to gather them for food. The worms are dried in the sun, the shell rubbed off by hand, when a yellowish kernel remains, like a small yellowish grain of rice. This is oily, very nutritious, and not unpleasant to the taste, and, under the name of *koo-chah-bee* (so pronounced), forms a very important article of food. The Indians gave me some of it; it does not taste badly, and, if one were ignorant of its origin, it would make nice soup. It tastes more like patent 'meat biscuit' than anything else I can compare it with.

"I will say in addition that *koo-chah-bee* was rather palatable. The waves cast these larvæ in little windrows on the shore; the quantity is large, the chief difficulty in collecting is to get it as free from sand as possible, and it is then dried on clothing or blankets. My guide, an old hunter there, told me that everything fattens in the season of the *koo-chah-bee*; that ducks get very fat, but their flesh tastes unpleasantly from it, and that the Indians get fat and sleek. There are many gulls about the lake at that season.

"The flies settle on twigs, spires of grass, etc., until nothing of the perch can be seen, merely a wand of closely clinging flies. They also at times rest on the water in great numbers."

Another species, *Ephydra hians*, is found in equally great quantities in Lake Texcoco, near the city of Mexico, and Professor Peñafiel, who has carefully studied the subject, has sent the writer the following notes concerning them: "It is of the eggs of this insect, I believe, that the greater part of the food products of this lake, known as *Ahuatlle*, is composed, and which is now used by the natives, who have preserved the customs of the ancient Aztecs in this same valley of Mexico. The natives cultivate in Lake Chalco a species of sedge (*Cyperus longifolius*) on which the flies will deposit their eggs in abundance. This sedge they make into bundles, which they carry to the Lake of Texcoco and let float upon the water till they are covered with eggs; they then remove and dry them, and separate the eggs by beating over a large piece of cloth. The eggs are then cleaned and ground into flour, which is called

Ahuatlle. This food is deemed suitable for those days in which the religious observances prohibit the use of flesh. It is prepared by mixing with hen's eggs and fried with fat into small cakes. The taste is similar to that of caviare, though hardly as pleasant.

The larvæ are also used as food, under the name of *Puci*.

The larvæ of species of *Drosophila* are frequently found in decaying fruit, preserves, etc.

The flies are but three or four millimeters long, and are of a yellowish color with transparent wings.



FIG. 545. — *Drosophila*, fruit-fly; a, larva.

In the Pupipara there are not many more than one hundred species known, but they are among the most curious in the whole order. The eggs are hatched and the larval stage passed within the body of the parent, and are extruded by the parent only when they are nearly ready to become pupæ. As one would suppose, the flies are not at all prolific, only a single one is brought forth at a time. The head is closely connected with the thorax, in the wingless forms largely concealed; the proboscis is firm and adapted for piercing, the legs are stout and provided with strong denticulated claws; the veins of the wings are present only in front, or at least the



FIG. 546. — *Olfersia*, bird-tick, enlarged.



FIG. 547. — *Hippobosca equina*.

posterior ones are rudimentary. The flies are wholly parasitic upon birds and mammals, moving about very quickly among the feathers and hair. A common species is *Olfersia americana*, found on several species of birds, such as the Virginia horned owl, several hawks, ruffed grouse, etc.; it has a smooth, horny, flattened, yellowish body. The genus *Lipoptena* is remarkable in that in the earlier state the flies have wings and live on birds, but later they seek quadrupeds, where they remain, and having no further use for their wings, they lose them. *Hippobosca* (from which this family, HIPPOBOSCIDÆ, takes its name) *equina*, is a winged species that lives on the horse. The sheep-tick, *Melophagus*, is wingless. Usually not many individuals infest a single animal, but instances have been known where more than a hundred specimens have been found on a single swallow.



FIG. 549. — *Nycteribia nycterowoli*, bat-tick, enlarged.

The NYCTERIBIDÆ are only found on bats. They are very remarkable, wingless, spider-like insects, with a very small head and the eyes either small or wholly wanting. They are small, rarely more than a sixth of an inch in length.



FIG. 548. — *Melophagus ovinus*, sheep-tick, enlarged.

The family BRAULIDÆ comprises only a single minute species, not two millimeters in length. The head is large, wholly without eyes, the thorax small and without wings, and the legs are short and stout, with strong pectinated claws. These degraded flies are parasitic upon honey-bees, especially the drones, living among the hair of the thorax; they are called bee-lice.

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ORDER IX. — APHANIPTERA.

The fleas are united with the Diptera by many entomologists, but at the present time the weight of authority is in favor of their separation as a distinct order under the above name. The characters which separate them are a thorax in which the three segments are distinct and nearly equal, the two last rings (mesothorax and metathorax) bearing short leaf-like appendages; and mouthparts adapted for piercing.



FIG. 550. — *Pulex irritans*, flea.

The order forms but a single family, the PULICIDÆ, embracing, besides the well-known fleas, the jigger-flea of South America. They are wingless insects with compressed bodies, small, round eyes, and mouth-parts adapted for sucking. The legs are long and stout, the hind pair especially so, giving these animals their well-known leaping powers. The relation-

ship of the order to the Hemiptera, Diptera, and Orthoptera are well marked.

In the genus *Pulex*, which embraces the fleas proper, the under lip is well developed. There are many species known, all of which lead a semi-parasitic life upon man and various other mammals. The eggs are laid on the hair of the host, from which they fall to the floor or ground, when the larvæ hatch and feed upon refuse of various sorts. The larval stage lasts about two weeks, and is followed by a pupal condition of about the same duration.

Fleas are very common upon cats and dogs, from which they frequently pass to the human being, causing considerable annoyance by their bites. The best preventative is Dalmatian insect powder (the pulverized flowers of *Pyrethrum*) which should be thoroughly rubbed into the hair of the victim. The kennels of dogs, and the mats upon which the cat sleeps, should also be occasionally sprinkled with the same powder.

The other genus of the group, *Sarcopsylla*, contains the famous jigger, chigoe, chique, or pique of tropical America. The adult female attacks any exposed portion of the body, especially the feet, and soon effects a lodgment beneath the skin. Here the abdomen of the parasite soon becomes distended with eggs, so that a painful or even dangerous ulcer is formed. Unless the female is soon extracted, the ulcer becomes filled with a large colony of jiggers. From the egg hatches out a larva very like that of the other genus, which lives upon the ground, there undergoing its transformations.



FIG. 551. — *Sarcopsylla penetrans*, female distended with eggs.

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ORDER X. — LEPIDOPTERA.

The order of Lepidoptera, which comprises the forms familiarly known as moths and butterflies, receives its name from the fact that its wings are covered with minute scales laid on much like the shingles on a roof. This character alone would be of little systematic importance, but we find associated with it many other peculiarities of structure, all of which show the group to be a natural one. The head is small and the mouth-parts are greatly modified, the maxillæ forming the long tongue, which, when not in use, is coiled up like a watch-spring, while the mandibles are obsolete. The wings are broad and membranous and are supported by numerous veins, the arrangement of which affords good systematic characters. The transformations are complete. The active larva (rarely footless) is provided with three pairs of thoracic legs, while on the abdomen occur from one to five fleshy appendages, the prolegs. The butterflies pass from the larva into a pupa or chrysalis which is naked or merely enclosed in a cocoon of leaves, etc., while the moths spin a cocoon of silken threads, inside of which the pupa is placed. In the pupa one can with little difficulty trace the parts of the perfect insect; but the cases which enclose the legs, antennæ, wings, etc., of the adult are all firmly united and not free, as for instance in the pupæ of the beetles. At the proper time the perfect insect emerges from the chrysalis skin, extends its various members which rapidly become firm and dry, and then the butterfly or moth begins its short but active life.



FIG. 552. Scales from wings of butterflies.

In the perfect state the Lepidoptera do no damage, the slight amount of food they take being in a liquid state; in fact they are unfitted for eating any solid substances. In their larval stages they are to be regarded as among injurious forms, for they feed upon plants and other objects that man regards as valuable. A few of the larvae of the moths are predaceous in their habits, while some of the Bombycidae repay the damage they cause to various plants by the valuable textile fibre, silk.

The large size and brilliant colors of many of the forms make them conspicuous among insects, and the butterflies have long been the favorites among collectors; but the moths, on account of their immense numbers, their innumerable variations, and the minuteness of many of the characters upon which systematic classification is founded, have been greatly neglected by naturalists, and in the following pages but a few of the more striking or more important forms can be noticed.

The Lepidoptera are divided into two sub-orders known, respectively, as the Heterocera or moths, and the Rhopalocera or butterflies, the distinctions of the popular names agreeing exactly with the limits of the groups recognized by naturalists.

SUB-ORDER I. — HETEROCERA.

This group of insects, popularly called moths, may be distinguished from the butterflies (Rhopalocera) by having the antennæ variable in form, and the wings seldom elevated in repose. The larger number fly only by night, or, if disturbed in the daytime, they fly only a short distance before alighting. Many of them have two simple eyes on the top of the head, one on each side, behind the antennæ and near the compound eyes; and the greater number have a frenulum or bristle attached to the first

rib of the hind-wing near the base, which passes through a loop on the under side of the fore-wing, thus holding the two wings together in flight.

Some of the moths are most gaily and gorgeously colored, while others are extremely plain and subdued in their attire. There is also a great range in size among these insects, from the great owl-moth (*Thysania agrippina*) of Brazil, the wings of which expand nearly a foot from tip to tip, down to the smallest mite of a tineid scarcely visible to the naked eye. The moths have a wide distribution, extending from the equator far into the polar regions; and while some species are quite restricted, being limited to a very small territory, others are found in every quarter of the globe, often in great abundance.

As a rule the moths are very prolific, some species laying as many as three or four hundred eggs; and while many give rise to only a single generation in a year, others have two, or in the warmer, temperate, or tropical regions, even three or four in a single season. Some of the species hibernate in the imago state, others pass the winter in the egg, and still others in the caterpillar state, either immediately after hatching, or when half or fully grown; but by far the larger number pass the winter in the pupa state.

The larvæ or caterpillars are composed of thirteen joints or segments, of which the head is the first. They have a pair of legs on the second, third, and fourth segments, and the number of prolegs on the abdominal segments varies in the different families. Some caterpillars are entirely smooth and naked, while others are clothed more or less



FIGS. 553-555. — Larva of moths.

densely with hairs, spines, bristles or protuberances, and in one family most of the species have a curved, tapering horn on the top of the last segment but one. Many of these spines or tubercles are hollow, and contain a fluid which escapes, giving off a very offensive odor, if the spines are broken. Some species produce a strong, stinging sensation if brought in contact with the hand, and even the moulted skins will produce the same unpleasant effect if handled too freely.

The caterpillars of most moths feed on living plants; a small number, however, feed on dead material, and a very few are predaceous in their habits. Some confine themselves to the leaves of a single species of plant, others feed on closely related species, while still others are very indiscriminate in their diet, attacking plants which are totally unlike with equal avidity. Some bore in the stems or solid trunks of trees, others attack the fruit only, while still others feed upon the seeds. A few minute species are very destructive to woollen fabrics of all kinds, and feed also on feathers, furs, and even dried plants. Some are especially destructive to grain in storehouses, and others do not hesitate to attack the very food in our pantries. Aside from the few silk-producing species, there is scarcely a single moth in all the world that can be regarded of any direct value to mankind.

We are far from having a satisfactory classification of the moths, but a division into the following families will answer the purposes of this work: Pterophoridae, Tineidae, Tortricidae, Pyralidae, Geometridae, Noctuidae, Bombycidae, Zygenidae, Aegeridae, and Sphingidae.

The moths of the small family PTEROPHORIDÆ, frequently called feather-wings or

plume-moths, have long, slim bodies and legs; and most of the genera are remarkable for having their wings divided into lobes or feathers. The caterpillars are somewhat fusiform or spindle-shaped, and have sixteen legs. Each segment bears a number of protuberances, from each of which arise several hairs varying in length. Many of these hairs are hollow, and are connected with glands beneath, which secrete a viscid fluid that fills these tubular hairs, and exudes through an opening in the top, in a dew-like drop, as stated by Dimmock. This clothing of the caterpillars frequently causes them to resemble so closely the hairy plants upon which they feed, that they are usually overlooked, except by the practised eye. The function of these glandular hairs may be protective in some way. These caterpillars do not spin a cocoon in which to pass their transformations, but simply attach themselves to a leaf or other object by their anal feet, and change to pupæ which are naked in some species but hairy in others. Some of these moths fly in the daytime, while others are on the wing only by night. The greater part of them are somewhat sluggish in their habits; and, when one is "flushed," a diligent search should be made, for others are almost certain to be found in the vicinity.

The insects associated in this family may be classed in three groups, according to the division of their wings. The highest group is composed of species which have undivided wings, and includes the European genus *Agdistis*, the South American genus *Stenopterycha*, and the North American genus *Scoptomyza*. The insects of this group have some resemblance to the Pyralidæ. In the next group, the moths have the fore-wings divided into two lobes and the hind wings into three. By far the greater number of the species fall into this group, and are divided into several genera on structural differences, such as the form of the lobes of the wings, the presence of a frontal tuft of hairs, the form of the legs, etc. In the lowest group, the wings are each divided into six lobes, and it includes only the genus *Alucita*.

Alucita hexadactyla of Europe and America expands about half an inch, and has each wing divided into six lobes or feathers, which are rounded at the apex and ciliated on both edges. They are of an ashy color with dark-brown markings and a black dot at the end of each lobe. The caterpillars are reddish pink or salmon colored, changing to yellowish white just before transforming to pupæ. They feed on the flowers of honeysuckle, and have but one brood in a year. The moths hibernate during the winter.

The gartered plume-moth (*Oecyptilus periscelidactylus*) is a representative of the second group, having the fore-wings divided into two lobes and the hind-wings into three. The wings expand about seven-tenths of an inch, and are of a yellowish-brown color, marked with dull, whitish streaks and spots. The mature caterpillar is about half an inch in length, of a yellowish-green color, with a transverse row of yellowish tubercles, from each of which arises a small tuft of white hairs. When done feeding, it spins a few silken threads on the under side of a leaf, to which it attaches the anal feet, and transforms to a rough, angular-looking pupa, which is pale yellowish green at first, but becomes reddish brown at a later period. These caterpillars feed on the grape, drawing together the terminal leaves, and living within the enclosure, either one alone, or two or three together. Only one brood occurs in a season.



FIG. 556. —*Pterophorus*.

Pterophorus monodactylus is a very widely distributed species occurring throughout Europe and western Asia, as well as in all parts of North America. The wings of this variable species expand nearly an inch, and are white, sprinkled with blackish

scales, or of a fawn color similarly sprinkled, and there is a brown spot near the cleft of the fore wings. The caterpillar feeds on *Convolvulus*, *Chenopodium*, *Atriplex*, and *Matricaria*.

Agdistis bennetii, of England, has undivided wings, and therefore belongs to the highest group. It expands about an inch, and is of a dark-gray color, sprinkled with brownish scales, with ochreous or rosy shadings. The caterpillar is of a greenish color, and feeds on sea-lavender (*Statice limonium*). There are two broods of this insect in a year, and they hibernate in the perfect state.

The TINEIDÆ form an immense group of insects, probably comprising twice as many species as any of the other families of moths. Although introduced here as a single family, it is more than probable that the group includes several as clearly defined



FIG. 557. — Cocoons of a Brazilian Tineid.

as the Tortricidæ or the Pterophoridæ. These insects are generally quite small, indeed some are the tiniest things imaginable, while others are of moderate size. It has been the remark of every writer, that, the smaller the species, the more splendid the coloring and the more sharply defined the markings. There are certainly no moths so gaily colored as some of the smaller species of this group; and, were they as large, they would surely vie with the most gorgeous of the tropical butterflies.

The Tineids are characterized by their small size, their bright metallic markings, the long fringes on the wings, and the long and narrow, almost lance-shaped wings. Some of the species with narrow wings have very short palpi; and those with wider wings, resembling the Tortricids, may be distinguished by having long, slim palpi, which curve up in front of the head, the last joint being very long, slim, and pointed. The caterpillars are mostly vegetable feeders, and, because of their small size and secluded mode of living, only occasionally become abundant enough to cause any considerable

amount of damage. A large number of them are called leaf-miners because they feed on the tissues of the leaves, beneath the epidermis, forming crooked and gradually enlarging channels, which are rendered visible on the surface on account of the whitish color of the overlying epidermis. Some feed in the stems of plants, a few are gall-producers, and still others feed on the roots of plants under the ground. A few species belonging to the genus *Tinea* feed on woollen fabrics, hair, feathers, etc. These are the moths *par excellence*; and in our English version of the Bible, as well as in the old English writings, when the term moth was used, reference was made to some one of these species. The word is still used to some extent in this restricted sense, but more frequently the term clothes moth is used.

Tinea pellionella, which expands half an inch, is a grayish moth with two or three darker obscure spots on the fore wings, and lighter-colored, silky hind wings. The head is covered with dull yellowish hairs. These insects are frequently seen in our houses, during the summer months, at rest on the walls or ceiling in the daytime, and flitting about by night in the darker parts of the room, and seldom going near a light. After the sexes pair the females deposit fifty or more eggs, which hatch in about a week, when the young caterpillars begin to feed, and at once construct portable cases of the materials on which they feed. These cases are of a cylindrical form, open at both ends, and lined with delicate silk. When the caterpillars have grown too large for their cases they split them down at one end, and fill in the space with new material, after which they enlarge the opposite end in the same manner. They never leave their cases, but, in feeding, put out a small part of the anterior end of their bodies, and, as they move about, drag the cases along with them. Their transformations are all passed in the cases. This insect, which has a world-wide distribution, feeds on woollen goods of all kinds, fur, hair, feathers, and also on insects in collections, and has always been regarded a notorious pest.

Tinea tapetzella has an expanse of about three-fourths of an inch, and is black on the basal half of the fore wings but white on the outer half, with a small black spot on the anal angle. The caterpillar makes covered galleries of the substance on which it feeds, and is destructive to woollen fabrics.

Tineola biselliella expands a little more than half an inch, and is of a pale yellow ochre color, with a reddish ochre-colored head. The hind wings are silky and nearly white. The caterpillar is of a dirty-white color, and makes no case, but fastens together with silken threads portions of the substance on which it feeds for a cocoon, in which it transforms to a pupa. This species, which is distributed all over the world, is particularly destructive to woollen fabrics, fur, hair, feathers, dried insects; and it is also said to attack dried plants.



FIG. 559. — *Tinea granella*: eggs, larvae, pupae, and adult.



FIG. 558. — Clothes moth, larva and pupa.

Tinea granella has been carried to nearly all the countries of the globe where grain is cultivated, and has proved a great pest, not only in grain in storehouses, but also in the field. The fore wings of the moth expand about half an inch, and are white, with numerous

nearly black spots so extended as to cover a large part of the wings. The hind wings are pale grayish. The females deposit thirty or more eggs on the kernels of wheat or other grain; and, as soon as these hatch, the young caterpillars eat into the grain, feeding on its substance, till they are mature, if it contains a sufficient quantity of food, otherwise they leave, and attack another which they attach to the first by their silken threads. At maturity they leave the grain, and spin a cocoon in some secure place where they pass the winter, changing to pupæ in the spring; and after a few weeks the moths emerge.

The cabbage *Plutella* (*Plutella rylostella*) expands about three-fourths of an inch, and has ashy-gray fore-wings, with an irregular whitish stripe along the hinder margin, and a similar one along the top of the thorax. The caterpillars are of a grayish color, with pale yellowish heads. When mature, they spin a loose, gauzy cocoon on the surface of a leaf, within which the pupa is readily seen. There are two or more broods in a year, according to the length of the season. This species has become established in all parts of the world, and is often so abundant on the outer leaves of cabbages and other cruciferous plants as to cause a great amount of damage.

The species of *Lithocolletis* are all minute, but most beautifully colored. The larvæ are all leaf-miners, and each species usually confines its depredations to a single species of plant. The moths fly rather sluggishly, and sometimes appear in large numbers. The only other form which we can mention is called the Angoumois grain-moth (*Sitotroga cerealella*); it appears to be a native of Europe, and has been known in this country for nearly a century, proving very destructive to wheat, barley, oats, and corn. The moths expand a little more than half an inch, and the fore wings are ochre yellow, with a few minute, black sprinkles. The hind wings are gray. The females lay from sixty to ninety eggs on the young kernels in the field or on the grain stored in bins. The eggs hatch in from four to seven days; and the minute caterpillars eat their way into the kernel, remaining in this state during the winter, in a cocoon which they spin in the grain, and within which they pass all their transformations. It is stated that they may be destroyed by heating the grain to a temperature of 130° F. for five hours, without injuring the vitality of the seeds.

The family of moths known as the TORTRICIDÆ is of considerable size and of wide distribution, extending from the Arctic to the most southern regions. While some species are found only in limited areas, others, as the codling-moth and the grape-berry moth have been carried to all parts of the world, wherever their food plants are grown. These insects, though small in size, are very prolific, and, unless reduced by their natural enemies, would cause an amount of damage to the plants or fruits which they attack entirely out of proportion to their diminutive size. They are generally of rather modest hues, though a few are of great elegance and remarkable for their beauty. They are rather crepuscular in their habits, the greater portion of them flying about sunset.

Their bodies are moderately stout, and the heads are clothed with rough scales which stand erect. The ocelli are present in the majority of the species; the palpi curved up against the front, or extended forward in a line with the body, sometimes twice or three times as long as the head. The antennæ are simple or finely ciliated, and, in a very few species, pectinated. Some species have the thorax smooth, while others have a tuft of scales on the posterior portion. The abdomen is without tufts, except the hairs at the end which are sometimes quite numerous, forming the so-called anal tuft. The legs are of medium size and length, the middle tibiæ having a pair of

unequal spurs at the end, and the hind tibiae a pair at the end and another pair in the middle. A few species have the hind tibiae densely clothed with hair-like scales, while some have a long tuft of hairs lying in a groove along the inside of the hind tibiae in the males.

The wings are comparatively wide; and in many species the costa of the fore wings has a sinuous outline, causing the insect to appear somewhat bell-shaped when the wings are closed. They often have tufts of scales over their surfaces arranged more or less in lines, and a few species have a deep excavation near the middle of the anterior margins or costa of the fore wings. The males of many species have the basal portion of the costa of the fore wings folded over on the upper side. The hind wings of some of these moths have, on the upper side, long hairs on the basal part of the median vein, while others are without them; and a few species have a separate membranous appendage attached to the anal border of the wing.

The caterpillars almost universally feed on the leaves of plants, rolling them up and feeding within, but when disturbed wiggle about in the most lively manner and escape quickly, letting themselves down by a thread of silk, and remaining till the danger is past. It is possible that this habit has been acquired in avoiding the attacks of insect-feeding birds, which tear the rolled leaves in pieces for the enclosed caterpillars. A very few are gregarious in their habits, feeding under a tent of silken threads which the community spin over the leaves. Some are borers in the stems of plants, others live in fruit, and one species, *Carpocapsa saltitans*, lives in the seeds of a species of *Euphorbia* in Mexico. If an infested seed be placed in the palm of the hand, the heat will affect the caterpillar so much that it will cause the seed to jump, sometimes to the height of a quarter of an inch, hence they are called "jumping-beans."

Texas caudana, a singular moth, which is comparatively common in Europe, expands about three-fourths of an inch, and is of a reddish-brown color. The fore wings are remarkable for their falcate outer margin, and the singular excavation on the middle of the costa. The caterpillar is green with a yellow head, and the body has the usual fine hairs from tubercles on the segments. It feeds on *Salix caprea*.

Cacaecia rosaceana is a common and wide-spread species in North America, having been reported from Labrador to Texas and from the Atlantic to the Pacific. It is subject to great variation, and has numerous food-plants. The caterpillars, which are green with black heads and thoracic shields, feed singly in the rolled leaves of apple, peach, cherry, plum, and numerous other plants. The moth expands an inch or more, and is cinnamon brown with a dark-reddish brown basal patch and with an oblique central band and spot on the costa before the apex. The hind wings are deep ochreous on the outer part, but fuscous within.

The cherry-tree Tortrix (*Cacaecia cerasivorana*), common everywhere east of the Rocky Mountains, has the remarkable habit of living, while in the caterpillar state, in a community comprising all which hatch from one lot of eggs. They enclose the leaves on the end of a branch in a web of silken threads, which they extend as more food is needed. The blackish excrements are deposited in a large dense mass inside of the web, and at maturity the ochre-yellow caterpillars transform within this black mass. When about to emerge, the pupae work themselves partially out in order that the moths may escape with ease. After the sexes pair, the females lay their eggs for the next year's generation. They feed on the leaves of wild and cultivated cherry.



FIG. 560. — *Cacaecia rosaceana*.

The perfect insects expand about three-fourths of an inch, and are bright ferruginous, with two brown spots on the costa, and one at the end of the cell of the fore wing. The hind wings are dull ferruginous, brighter towards the apex.

The spruce Tortrix (*Tortrix fumiferana*) of the United States has recently been so abundant in some portions of this country as to cause a vast amount of injury to the spruces and other evergreen trees. The green, oval, flattened eggs are laid in two overlapping rows on the upper side of the leaves. These hatch in ten days, and it is uncertain whether the caterpillars feed at all before the next spring; but there is no doubt that they hibernate either as young or partially grown caterpillars. They reach maturity in the latter part of June, when they are nearly an inch in length, of a dark-brownish color inclining to greenish yellow between the segments, with black heads and thoracic shields, and several pale-yellowish tubercles with short hairs on each segment. These caterpillars spin a few threads over the leaves on the smaller twigs; and, when mature, they transform to pupæ in these places.

The moths, which expand about three-fourths of an inch, emerge in about a week, and are of an umber-brown color, the fore wings being marked with whitish or light gray. There is considerable variation in the color of the fore wings, many examples inclining more or less to rust red instead of umber brown.

The codling-moth (*Carpocapsa pomonella*) occurs wherever apples are grown. In the colder latitudes there is only one annual brood, but in warmer climates there are two. The females lay about fifty eggs, but seldom more than one on a single fruit,



FIG. 561. — Codling moth.

the eggs being deposited in the blossom-end of the apple, when it is just beginning to form. The eggs hatch in a short time, and the young caterpillars eat their way in to the core, where they remain feeding for about three weeks. They are then nearly an inch in length, of a dull whitish color with pale yellow heads, and a few short hairs over their surface. They escape through the sides of the apples, and conceal themselves beneath the bark, or in some other protected place, where they spin tough, whitish cocoons, and remain in them in the caterpillar state during the winter. In the spring they transform to pupæ, and the moths emerge in season to lay their eggs upon the young fruit. Although the caterpillars are among the most common and destructive, yet the perfect insects are seldom seen, as they fly only at night, and are not attracted to light. They expand a little over half an inch, and the fore wings are gray, with dark, wavy lines, and a bronze spot on the outer margin. The hind wings are brown.

The PYRALIDÆ comprise a large number of insects, which are quite generally distributed over the world. They usually have slim bodies with long legs, but there are many exceptions to this. Both labial and maxillary palpi are present, though the latter are sometimes very minute, or represented only by a tuft of hairs concealed behind the others. There are three principal groups: the Crambinae, the Phycinae, and the Pyralinae proper. The fore wings are broad in the first of these; and, when the insects are at rest, they are closed so as to form a triangle over the body. In the other groups they are long and narrow, being folded closely around the body. The hind wings are very broad in all the groups.

The Crambinae contain a large number of species many of which are grass-feeders, while some are borers in the stems of corn, sugar-cane, etc. The genus *Crambus* includes a large number of species, which are quite uniformly distributed over the globe. They feed on the grasses, so far as known, and sometimes become so abundant as to do a great amount of damage.

The vagabond *Crambus* (*Crambus vulgicarpellus*) of North America expands about an inch; and the fore-wings are of a light ochre-yellow color, sprinkled with fuscous scales between the veins. There is a terminal row of black dots, and the fringes are golden with a metallic luster. The hind wings are pale clay yellow. The eggs have a reticulated surface, and are pale yellow when laid, but change in a few days to bright orange. The mature caterpillar is about three-fourths of an inch long, pale purplish green, with a black head, and with the shield and tubercles on the segments of the body brown. They are nocturnal in their habits, and form a silken tube covered with their greenish castings, near the roots of the grass. When done feeding, they leave these tubes and spin delicate cocoons just beneath the surface of the ground, and pass their transformations in this state. The genus *Argyria* includes a small number of most lovely species, whose fore-wings are snowy white with a beautiful satin lustre, and marked with bright orange. They frequent grassy spots, and the caterpillars probably feed on the grasses. These moths are mainly confined to North and South America, though one or two species have been found in other parts of the world.

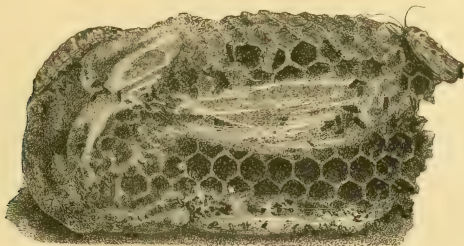


FIG. 562. — *Galleria mellonella*, bee-moth.

The only species of the genus *Galleria* which needs mention is the bee-moth. *Galleria mellonella* is a great pest to apiculturists in all parts of the world where it has been introduced; for the caterpillars are often very numerous in the hives, and run their silk-lined galleries in all directions through the wax, on which they feed, destroying the cells and rendering the whole mass foul, much to the discouragement of the bees. These caterpillars are about an inch in length, dirty white, with brownish heads and thoracic shields, and with a few scattered hairs over their bodies. At maturity they crawl into some corner or crevice of the hive, where they spin their tough, whitish cocoons in which they pass their transformations. The moth expands an inch or a little more, and the fore wings, which are dusty gray, and more or less streaked with purplish brown, are scalloped on the outer margin. When at rest they close the wings along the sides of the body, like the roof of a house. There are two broods in a year, and the winter is passed in the pupa state.

The gooseberry fruit-worm (*Dakrnum conrotutella*), which occurs both in Europe and America, has an expanse of nearly an inch. The fore wings are pale gray, crossed near the base by a dark diffuse band, which is divided by a whitish line. The outer part of the wing is darker gray, with a zigzag whitish line, and a terminal row of

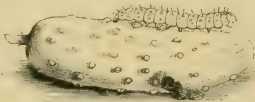
blackish dots. There is a pair of blackish dashes at the end of the cell. The females deposit their eggs singly on the young gooseberries; and, when the caterpillars escape from the eggs, they burrow into the berries, feeding on the pulp within. As they increase in size, they fasten several berries together by silken threads. The mature caterpillars are about three-fourths of an inch in length, of a pale-greenish color, with light-brownish heads and thoracic shields. When done feeding they descend to the ground and spin silken cocoons among the fallen leaves, where they remain during the winter, the moths emerging the next summer.

FIG. 563. — *Dakrura convolutella*.

Prof. J. H. Comstock has described two other species of *Dakrura*, the caterpillars of which are predaceous. The first, *Dakrura coccidivora*, feeds on the cottony maple scale (*Puleinaria innumerabilis*), and other species of coccids; the second, *Dakrura pallida*, feeds on the eggs of certain species of bark-lice.

The leaf-crumpler, *Phycis indiginella*, of North America, expands about three-fourths of an inch. The fore wings are pale brown, marked with silvery white on the costal portion, and crossed by several whitish lines. The hind wings are pale brownish white. The eggs are laid in July, and the caterpillars draw together and crumple the leaves on which they feed. They form peculiar, horn-shaped and twisted cases of silk, interwoven with their dried excrements. The caterpillars remain in these cases feeding during the autumn, and also hibernating in them in the winter. In the spring they revive, continue feeding, transform to pupæ, and the moths emerge in June.

The melon-caterpillar, *Eudiotis hyalinata*, which occurs throughout the greater portions of North America and South America, expands about an inch. The wings are of a beautiful, pearly, iridescent white, with a broad, black, or purplish brown band on the outer margin, and on the costa of the fore wings. The mature caterpillar is about an inch and a quarter in length, of a yellowish green color, and spins its cocoon in a fold of the leaf, within which it transforms to a pupa, and the moth emerges in a short time afterwards. This insect is particularly destructive to melon plants, and not only devours the leaves, but eats into the melons, and also cucumbers

FIG. 564. — *Eudiotis nitidalis*, larva and adult.

and pumpkins, at all stages of their growth, sometimes excavating shallow cavities, and at other times penetrating directly into the substance of the fruit. Closely related to this species is *Eudiotis nitidalis*, which is common in some parts of the south, feeding on cucumbers, and having similar habits to the melon-caterpillar.

Asopia farinalis, the meal-moth, now common everywhere, expands about an inch. The fore wings are yellowish brown across the middle, and the base and outer edge are chocolate-brown. The median shade is limited by a white line on each side. The hind wings are smoky brown, crossed by two irregular, white lines, and a row of brown spots along the outer margin, which are largest towards the anal angle. The

caterpillar is said to be of a dull whitish color, with the head, thoracic, and anal shields reddish brown. They feed on meal, flour, straw, etc.

Pantographa limata, of North America, expands nearly two inches. All the wings are straw-yellow, beautifully and intricately marked with purplish brown. The caterpillars feed on the leaves of bass-wood, cutting them a little more than half way across the middle, and rolling the outer part of the leaf into a cone, which they close at each end, remaining and feeding within. They are bright green, with pitchy black heads and thoracic shields, and with a few fine short hairs scattered over the surface of their bodies. They closely resemble some of the tortricid caterpillars, both in structure and habits, but the perfect insects are typical pyralids of the first group. Only three species belonging to this genus are at present known.

Mesographa stramentalis, common both in Europe and America, expands about an inch. The fore wings are straw-yellow, crossed by two curved or angulated brown lines. A brown shade rests on the outer margin, enclosing a small yellow spot, and the veins are marked with brown. The hind wings are very pale yellowish white, with brown terminal and subterminal lines, the latter rather faint. The females lay their flattened, oval, yellowish eggs, which hatch in about ten days, on the leaves of cruciferous plants, in mid-summer, and the caterpillars feed on these leaves for about a month, moulting three times before reaching maturity, after which they descend to the ground, spin an oval cocoon either among the leaves or just beneath the surface of the ground, where they remain in this state till the following spring, when they transform to pupæ, and the moths emerge in July or August.

The GEOMETRIDÆ or PHALEXIDÆ form a family of great size, being exceeded in numbers among the Lepidoptera, only by the noctuids and tineids, and probably equalled only by the pyralids and tortricids. They are found widely distributed over the globe, and the caterpillars of many species have proved very destructive to some of our most important vegetable productions. The moths have rather long, slender bodies, the thorax without tufts or crests. Ocelli are present in some species, and absent in others. The antennæ are either simple, ciliated, or pectinated. The fore wings are large and triangular; the outer margin, which is either rounded, more or less falcate or angulated, is nearly as long as the hinder margin. The hind wings are ample, though sometimes considerably smaller than the others, and have their outer margins rounded, entire, dentate, or more or less tailed in a few exotic species. In some, the females are wingless, or have only rudimentary wings, which are useless for flight. There are sometimes slight tufts of hair-like scales along the back and sides of the abdomen.

The caterpillars are slender and naked, usually with two pairs of abdominal legs, though rarely they have three or four pairs. This deficiency causes them to move along with a looping gait, and hence they are often called 'measuring-worms,' from which fact the family name was given them. These caterpillars live on the leaves of plants, with the exception of a few which bore into seeds. The pupæ are rather slender, green, or variegated in color, and enclosed in slight silken cocoons or cells in the ground.

The species of geometrids found in North America are possibly as well known as those of any group of moths, thanks to the able monograph of Dr. A. S. Packard, Jr., who has described and figured nearly every species. Our space, however, will allow us to mention but a very few of the forms.

Our first form is called the lime tree winter moth, *Hyphernia tiliaria*. It occurs

throughout the northern portions of the United States and Canada. The fore wings of the male moth expand two inches or more, and are of a dull yellowish color sprinkled with brown, with two brown lines across them, and a brown dot on the end of the cell. The portion of the wing beyond the outer line is usually somewhat darker. The hind wings are much paler, sprinkled with brownish, with a dot on the end of the cell, of the same color. The female is wingless, yellowish white, sprinkled with black along the sides, with two black spots on the top of each segment, except the last, which has but one. The eggs are laid in the autumn, in clusters, on the branches of trees. They are oval, of a pale yellow color, and covered with a network of raised lines. They hatch early in the spring, and feed on the leaves of apple, basswood, elm, and hickory.

Two distinct species of geometrid moths are known as canker-worms; and since they resemble each other both in appearance and habits, it is not surprising that they have been included under one common name. The males have well-developed wings, but the females are wingless.

Anisopteryx pometaria, sometimes called the fall canker-worm, emerges from the ground late in the fall, even after quite heavy frosts, and ascends the trunks of trees. The females deposit a hundred or more dull whitish eggs, in a cluster, exposed on the twigs or branches. These eggs are flower-pot shaped, attached by the smaller end; and the larger, or exposed end, has a central depression and a dark ring near the outer edge. It sometimes occurs that the females crawl up on the side of buildings, and deposit their clusters of eggs far from the trees or any suitable food for the caterpillars. The eggs hatch the following spring, at the time the young leaves begin to unfold. The mature caterpillar is about an inch long, with only three pairs of abdominal legs. They vary in color, from greenish yellow to dusky or dark brown, with broad yellowish or pale stripes along each side. When not feeding they take a rigid position, either along the twig on which they rest or at an angle of about forty-five degrees, resembling, both in color and position, a dead twig, and thus avoid detection. After they are done feeding they descend to the ground, either on the trunk of the tree or by means of a thread which they spin, and burrow to the depth of several inches, where they spin their buff-colored cocoons of silk mixed with particles of earth. They remain in the pupa state, in the ground, during the rest of the summer, and the perfect moths emerge late in the fall, as stated above.

The males, which expand nearly an inch and a half, have brownish gray fore wings, crossed by two irregular whitish bands, the outer one of which enlarges on the costa, forming a whitish spot. The hind wings are grayish brown, with a blackish dot near the middle, and an indistinct band crossing beyond. The female is ash gray, a little more than a third of an inch long; and the abdomen is greatly distended with eggs, giving the insect a broadly oval outline. The antennæ are simple.

A. vernata, usually called the spring canker-worm, emerges from the ground in the spring, though a few make their appearance in the fall. The wingless females ascend the trees and deposit their pearly, oval shaped eggs in crevices of the bark, to the number of a hundred or more. These eggs hatch at about the same time as those of *A. pometaria*, and the mature caterpillar closely resembles that of the other species, but has only two pairs of abdominal legs. They are also similar in their habits, and descend into the ground at the same time, but form a more fragile cocoon. The male moth, which expands about an inch and a quarter, has ash colored or brownish gray fore wings, with a silky lustre. A broken whitish band crosses the wing, near the

outer margin, and also three interrupted brown lines at nearly equal distances apart. There is also an oblique black dash near the apex, and a fine black line along the base of the fringes. The hind wings are pale ash-colored, with a dark dot in the middle. The female is pale gray, about a third of an inch long, with a stout body and a retractile ovipositor. The abdominal segments of both sexes have two transverse rows of small reddish spines, and the antennae are ciliated. Both species feed on the leaves of apple, plum, cherry, elm, linden, and many other trees. They are found in greater or less abundance from Maine to Texas.

Rheumaptera hastata is a widely distributed species, occurring throughout the northern and central portions of North America, Europe, and Siberia. The wings expand nearly an inch and a half, and are black, with two white bands across them, one before the middle the other a little beyond; and besides these there are often a few quite irregular white lines on the remaining portions. The hind wings are entirely black, or with more or less conspicuous white bands across them, corresponding to those on the fore wings. The body is black, with slender white lines on the edges of the segments of the abdomen. This moth is subject to great variation in the amount of white on the wings. The caterpillar is brown, or blackish brown, with a darker line along the middle of the back, and a row of horse-shoe-shaped spots on the sides. This species is gregarious, and feeds on the leaves of birch and sweet-gale.

The large magpie moth (*Abraxas grossulariata*) is widely distributed through Europe and Northern Asia, and is generally very abundant. The wings, which expand an inch and a half, or more, are white, with numerous black spots, placed in transverse rows, five on the fore and three on the hind wings. The fore wings are also ornamented with an orange blotch at the base, and a band of the same color beyond the middle, between the third and fourth rows of black spots. The caterpillar is creamy white, with numerous black spots, two or three of which, on the top of each segment, are large and conspicuous. A fine reddish orange line runs along the side near the spiracles. This species feeds on currant, gooseberry, hazel, etc. The caterpillars hibernate when quite small, passing the winter without feeding. In the spring they revive, feed again until they reach maturity, when they pupate; and the moths emerge in July or August, the sexes pair, and the females lay their eggs for another generation.

The family of moths known as NOCTUIDÆ contains a larger number of species than



FIG. 565. — *Rheumaptera hastata*.



FIG. 566. — *Abraxas grossulariata*.

any other, with the exception of the Tineidae. They are very generally distributed over the surface of the globe, and many are exceedingly destructive to agricultural products. The majority of these moths are of dull colors, yet some are clothed in the gayest plumage. There is, perhaps, as great a range in size, if not greater, than in any other family, for while some have an expanse of wings of half an inch, or less, others are of comparatively gigantic proportions, expanding from eight to ten inches. The typical noctuids are rather stout-bodied insects, generally with narrow fore wings, which, when at rest, are brought together along the back, and the hind wings folded under them. They fly, almost without exception, in the night; and the caterpillars of many of the species are nocturnal also in their habits, hiding by day under sticks or stones, or, as in the case of the so-called cut-worms, burrowing into the ground. The antennae are about two-thirds as long as the fore wings, threadlike, tapering towards the outer end, entirely simple in some species, but with fine cilia in others. The head is usually globose, quite closely attached to the body, with the front smooth, or with variously formed protuberances. The eyes are naked in many of the species; but others have fine, short hairs between the facets, and still others have hairs above and below, in the form of lashes. Two ocelli are generally present near the base of the antennae. The labial palpi are well developed, and, in some species, turned up over the head, extending along backwards over the thorax. The tongue is comparatively long in most of the species, and the collar, in a few, has the scales turned forward over the head. Some have the scales of the thorax turned up more or less in tufts, while others have the vestiture smooth. A few species have one or more tufts along the top of the abdomen. The legs are stout, the middle and hind tibiae having a pair of spurs at the end, and the hind tibiae a pair near the middle, also, while the fore tibiae have a spine (tibial epiphysis) on the inside. Many species have their legs armed with sharp spines, and sometimes clothed, more or less densely, with hair-like scales.

The eggs of the Noctuids are of various colors, and differ much in their form and markings. They are deposited singly or in clusters, and the duration of the egg state varies much in the different species. The caterpillars are smooth and cylindrical in many species, but with spinose tubercles in others. They all have six true legs, and the majority have ten prolegs or abdominal feet; but a few have less, some having so few that in moving they have a looping motion, like the geometers. The noctuids are attracted in various ways. Many of them, in common with other nocturnal moths, will come, on warm, dark nights, to any strong light; and their eyes often glow like coals of fire as they rest upon the glass near the light. Some are drawn to strongly fragrant flowers, and also to sap exuding from trees, as well as to baits of molasses or other odorous substances which are used by collectors; and at times they are so intent on feeding that they are not disturbed even when the full glare of a lantern is turned on them. Some species are attracted to flowers alone, others only to light, others to sugar, and still others may be obtained by either of these methods.

The largest noctuid known at present is the gigantic *Thysania agrippina* of Brazil. This monster moth measures eight inches or more between the tips of its extended wings, and some examples are said to expand nearly a foot.

Erebos odora is the largest noctuid which has been found in North America up to the present time. It expands six inches, or more, and is of a dark brown color, sprinkled with gray scales. The wings are crossed by numerous light and dark wavy lines, and the reniform spot is black, with a few scattered blue scales, and encircled by brownish yellow. There is much variation in the depth of coloring in these moths.

This gorgeous king of the night has been found from Maine to Brazil, and Walker states that it has been "caught off the coast of Brazil, one hundred and twenty miles due east of Espirito Santo." The caterpillar and food plant are unknown.

The genus *Catocala* includes a large number of species of great interest and beauty. Many of the species have beautifully colored hind wings, which, however, are entirely concealed by the others when they are at rest. They fly only by night, passing the day, generally, it is said, upon the trunks or branches of trees, whose bark their fore wings resemble in color so much that they are not easily seen. Occasionally, however, the gray-winged species may be found concealed on fences. North America seems to be the great metropolis of these moths, for a larger number of species has been found here than in all other parts of the world together.

The red under-wing, *Catocala nupta*, of Europe, expands about three inches. The fore wings are gray, with the usual spots and lines of a darker gray. The hind wings are red, with a broad black border and a broad, though much indented, black



FIG. 567. — *Catocala nupta*, red under-wing.

central band. Of our American species we can mention only the plum-tree Catocala, *Catocala ultronia*, which expands about two inches and a half. The fore wings are of a rich umber-brown color, darkest on the hind margin, with a broad, diffused, ash-colored band along the middle. The usual lines crossing the wings are brown, and very zig-zag. The hind wings are deep red, with a broad black band along the outer margin, and a much narrower one, of the same color, across the middle. The caterpillar feeds on the leaves of the plum, and when mature is about an inch and a half in length, tapering from the middle segments towards each end.

Drasteria crechea is an extremely common moth in all parts of this country. It is one of the earliest on the wing, and specimens of the second brood are often found quite late in the autumn. It frequents open, grassy fields; and, though flying freely by night, it may be started up in the daytime, when it will make a short, rapid flight, and alight suddenly. The wings of the moth expand about an inch and a half, and are comparatively wide. The fore wings are grayish brown, with darker bands and dots. One band crosses the wing from the basal third of the costa, and at right angles with it; another starts from the costa half way between the last one and the apex, and

extends nearly across; and there are two spots a little before the apex. The outer edge is widely margined with brown. The hind wings are brownish, and the outer half is crossed by two darker bands. The caterpillar feeds on clover, and when mature is about an inch and a quarter in length. It is reddish brown, with many longitudinal lines and stripes of a darker shade. There is a double whitish line along the back, and a stripe of dark brown on each side.

Rhodophora florida is one of the most lovely and interesting of the noctuids, and is quite common at night about its food plant, the evening primrose. Its fore wings expand about an inch and a quarter, and are bright pink or rosy red from the base to the subterminal line, beyond which they are pale-yellow, like the flowers upon which they feed. The hind wings are white. The eggs are dull yellowish pink, marked with vertical striae, which run into each other before reaching the top. There is but one annual brood in the northern states, and perhaps there are no more farther south. This little moth is remarkable for its beauty, and for the habit of concealing itself in the daytime, in the partially closed flowers of the evening primrose, in such a manner that only the tips of its wings, which are of the same color, are visible between the petals. The caterpillars are equally fond of the wild and cultivated species of *Enothera*, feeding not only on the petals but boring into the buds and young seed-vessels. When not feeding they rest along the sides of the smaller stems, or in the seed-pods, which they resemble so closely in color that they are not easily detected.

The cotton-worm, *Abtia argillacea*, is distributed from Maine southward through the United States, Mexico, and South America as far as Brazil. The fore wings of the moth, which expand nearly an inch and a half, are light brown, tinged with olive green and wine color. The reniform spot is black or grayish, and the usual lines crossing the fore wings are wavy, and of a reddish color. The eggs are "circular, much flattened, and marked with ridges radiating from the centre of the top." They are about one-fortieth of an inch in diameter, of a beautiful bluish-green color when first laid, but change to a dirty white before hatching, which occurs in from three to six days, according to the time of year. The young caterpillar is of a very pale green color, with a pale-yellow head. After five moults it reaches maturity, being at that time about an inch and three-fourths in length, of a light-green color, striped with white and black, and spotted with black and yellow. In many individuals the black stripes are wanting. After the caterpillar is done feeding it folds one edge of a leaf over its body, by means of its silken threads, and then spins a delicate cocoon, in which it transforms to a brown pupa. There are probably six or seven broods a year in the extreme southern states, but farther north there are less; while in the New England states there is doubtless but one. This insect feeds upon the leaves of the cotton-plant, and causes an immense amount of damage. Professor Riley has estimated that during years of general prevalence of the cotton-worm they cause an annual loss of thirty millions of dollars in the cotton-growing States. Its food plant in the north has not yet been discovered.

Pyrophila pyramidoides of North America expands about an inch and three-quarters. The fore wings are dark brown, marked with dull white, the portion outside of the transverse posterior line being much lighter than the rest of the wing. The hind wings are pale copper red, with the apex brown. The mature caterpillars are nearly an inch and a half in length, whitish green, with a white stripe along the middle of the back, a bright yellow one along the lower part of each side, and a similar but fainter one above, which follows the outline of the peculiar prominence on the top

of the twelfth segment. When they are done feeding they descend to the ground, where they spin light cocoons among the dead leaves, or other materials, and transform to pupæ. This species feeds on the leaves of grape, thorn, plum, raspberry, poplar, and probably other trees and shrubs.

The army-worm, *Heliothrips unipuncta*, has a remarkably wide distribution, occurring in this country everywhere, from Maine to Texas, and from the Atlantic to the Rocky Mountains. It has also been reported from South America, Europe, and Australia. The moth expands nearly two inches, and the fore wings are yellowish drab, sprinkled with black scales. A small white spot rests on the median vein, at the end of the cell, and the transverse posterior line is represented by a row of black dots across the wing, on the veins. A dark shade extends from the apex obliquely down and in as far as the above-named row of dots. The hind wings are smoky brown, with darker veins.



FIG. 568. — *Heliothrips unipuncta*, army-worm moth.



FIG. 569. — *Leucania unipuncta*, larva, army-worm.

The female moth deposits her eggs between the sheath and stem of grass, or in the fold of a leaf near the base, in rows containing from five to twenty or more, covering them with a white, glistening fluid, which fastens them to the leaf, and draws the edges together so that they are nearly or quite concealed. The egg is white, nearly spheroidal, about one-fiftieth of an inch in diameter, and hatches in from eight to ten days. The newly hatched army-worm is so small, and so nearly the color of the grass, that it is generally overlooked, even when present in large numbers. It grows rapidly, reaching maturity in from fifteen to thirty days, during which time it makes five moults. It is then about an inch and a half long, pale green on the under side, with longitudinal stripes of dark gray or blackish, alternating with stripes of greenish or yellow on the upper side. In a short time the caterpillar works its way down into the ground, where it transforms into a dark-brown pupa, about three-fourths of an inch in length. After remaining in this state about twenty days the moths emerge, and fly only by night, concealing themselves during the daytime.

There are several broods in a year in the southern parts of the United States, but probably only one in the more northern regions. Professor Riley states that this insect hibernates in both the caterpillar and imago states, and probably also in the pupa, particularly at the north. The food plants of this species are the grasses, both wild and cultivated. At times these insects become so abundant in certain localities, that every plant which can possibly serve as food is completely destroyed, after which they move off to other fields, in vast numbers, in regular order; and from this habit they have received their common name.

The stalk-borer, *Gortyna nitela*, expands about an inch and a quarter, and the "fore wings are of a mouse-gray color, finely sprinkled with Naples-yellow, and they have a faint lilac hue, but are distinguished mainly by an arcuate, pale line running across their outer third." The caterpillar is "of a livid hue when young, with light stripes along the body. When full grown, it generally becomes lighter, with the longitudinal lines broader. This caterpillar bores into the stems of potato, tomato,

dahlia, aster, and other plants. It has also been found eating into the cobs of growing corn, and into strawberries.

The zebra caterpillar, *Mamestra picta*, is a common species in the United States. The moth expands about an inch and a half, and the fore wings are of a beautiful rich purplish-brown color. The reniform and small orbicular spots are grayish, while the usual lines are generally wanting. The head and thorax are of the same color as the fore wings. The hind wings are white, tinged with brownish along the outer edge. The mature caterpillar is about two inches in length, of a velvety black color, with two lateral yellow stripes on each side, between which are numerous irregular, fine, transverse, white lines. The head and legs are reddish. This is one of our most beautiful naked caterpillars. When done feeding it transforms to a pupa in a rude cocoon formed just beneath the surface of the ground, where it passes the winter. There are two broods in a year in some parts of the country. This species feeds on a great variety of plants, among which are many of the Cruciferae, as cabbage, turnip, etc., and also on clover, honeysuckle, snowberry, and many others.

The caterpillars of a large number of moths, belonging mainly to the genus *Agrotis*, are called cut-worms, because of their remaining beneath the ground during the day, and coming up in the night to feed on plants, often when only a few inches high, which they cut off near the surface of the ground. Some of them, however, ascend trees and greatly injure the buds and leaves. These are called climbing cut-worms. The variegated cut-worm, *Agrotis saucia*, one of the climbing species, which is widely distributed both in Europe and America, expands an inch and three-quarters. The fore wings are of a grayish-brown color marked with brownish black but subject to great variation. The hind wings are whitish, shaded with pale brown towards the outer margin. The eggs are "round and flattened, of a pinkish color, and very prettily ribbed and ornamented." They are laid on the twigs of trees, in elongated patches containing several hundred arranged side by side. The young caterpillars are of a dull-yellowish color with darker spots. They remain on the trees till after the first moult, when they descend and conceal themselves in the ground during the day. The mature caterpillar is nearly two inches long when in motion, and is of a dull flesh-color, mottled with brown and black, with elongated, velvety black markings on each side. The caterpillar, when done feeding, forms a smooth, oval cavity in the ground, in which it passes its transformations. These caterpillars feed on the leaves of apple, cherry, peach, and various other plants.

The North American species, *Apatela oblonga*, which expands about an inch and three-quarters, has gray fore wings with a row of blackish dots along the outer margin, and a broken, transverse posterior line. The reniform and orbicular spots, and also the transverse anterior line, are faintly indicated by black scales. The hind wings are white, with a few minute dark spots along the outer margin. The mature caterpillar is about an inch and a quarter in length, "of a deep velvety-black color, with a transverse row of tubercles on each segment, those above being bright red, and set in a band of the same color extending down each side. From each tubercle there arises a tuft of hairs, those on the upper part of the body being red, while below they are yellowish or mixed with yellow. On each side of the middle of the back is a row of bright yellow spots, two or more on each segment, and below these, close to the under surface, a bright yellow band deeply indented on each segment." This caterpillar is very beautiful, and cannot fail to attract attention when present on the plants even in small numbers. When done feeding, it draws together a few leaves or other loose

material with a silken thread, forming a rude case within which it transforms to a pupa. There are two broods in a year, and the caterpillars feed on the leaves of apple, peach, willow, grape, raspberry, strawberry, and smart-weed.

Platygeura furcilla expands about two inches. The fore wings are ashy white, dusted with fine, dark scales, and the usual lines crossing the wings are black. The hind wings are whitish, with a broad, obscure, dusky submarginal line. The mature caterpillar is an inch and five-eighths in length, with the head and legs red. The body is dull red, and much mottled with irregular, broken stripes of gray, whitish, and black. The surface of the body is hairy, with several pencils of hairs one-fourth of an inch in length. It feeds on white pine.

The BOMBYCIDÆ is a family of considerable extent, but the species are by no means as numerous as in several of the other families of moths. The species vary so much that some entomologists have arranged them in several families, but it is preferable not to separate them. The majority of these moths have stout, hairy bodies, without tufts of scales or hairs except in rare cases. Their heads are comparatively small and sunken, and the mouth-parts are obsolete in a majority of the species. The antennæ are broadly pectinated in the typical genera, at least in the males, and the ocelli are present in some, but not in all the species. The wings are generally broad, and in many species are gaily colored, while others are very plain. These moths have long been noted for the strong attracting power which the virgin females exert on the males, drawing them from long distances, and often in considerable numbers. Collectors of these moths expose the unimpregnated females in suitable cages; and, in favorable weather, often secure a large number of males which are attracted to the cages containing the other sex. Browne states that he knew of a case where over sixteen hundred of the males of a certain species were caught in one day by the attractive power of seven or eight females. This method of collecting is called "assembling." Not only males of the same species, but also of those which are nearly related are attracted, and, when they are permitted to pair, produce hybrids as a result.

The caterpillars are thick and hairy, or have more or less bristly spines over their bodies; and, with few exceptions, they spin cocoons in which they pass their transformations. The silk of which some of their cocoons are made is manufactured into various fabrics of great value and importance to mankind. In fact, the common silkworm, *Bombyx mori*, must be regarded as the most useful of all the insect tribes, since it furnishes employment to a large number of people in many countries, who are employed in raising the caterpillars and obtaining the cocoons, which are afterwards unwound and manufactured into such an endless variety of fabrics.

At the beginning of the bombycids we meet a group of boring moths, of which *Xyleutes robinæ* may be taken as a type. The larvæ bore in the stems of various trees and plants, the species figured attacking the red



FIG. 570. — *Xyleutes robinæ*.

oak and locust, while others attack the roots of the hop, etc. In these forms the wings are rather membranous and strongly veined, recalling forms like the sialids among the Neuroptera.

The puss moths are noticeable from the fact that the abdomen of the larvæ ends in two long tails. They are brightly colored. That of the European *Stauropus fagi* is a very curious form, remarkable for the great length of its thoracic legs, which are nearly as large, proportionately, as those of the adult. Our *Cerura borealis*, the larva of which closely resembles that of the European *Harpyia vinuli* in the disposition of its markings, feeds upon various poplars and willows. The moth, when at rest, always extends the first pair of its hairy legs beyond the head.



FIG. 551. — a, *Harpyia vinuli*, b, cocoon; c, larva; d, larva of *Stauropus fagi*.

The next group contains a number of forms with stout bodies which are covered with quantities of long and closely set hairs, giving a very woolly appearance. The tent-caterpillar, *Clisiocampa*, is well known, forming its silken webs in the branches of neglected orchards. These webs are spun by the caterpillars, and sometimes harbor three or four hundred of these black and yellow larvæ. When the caterpillars are not feeding, they may be found sheltered by the tent; but, when impelled by hunger, each one, as he leaves the house, spins a silken thread so that he may find his way back after the demands of appetite are answered. Allied to the tent-caterpillar are the genera *Gastropacha* and *Totype*, both represented in our fauna.

Eacles imperialis, a yellowish moth with brownish or purplish markings, is one of our largest and most striking bombycids, and, together with the genera *Anisota* and *Hyperchiria*, forms a series of forms many of which, like the Attaci, have the wings

ornamented with eye-like spots, but can readily be distinguished from it by the fact that the hind wings extend but little behind the abdomen.



FIG. 552. — *Hyperchiria io*.

The Io Moth, *Hyperchiria io*, one of the most showy and beautiful of the North American species, has an expanse of wings of about three inches. The males

are of a deep-yellow color, with two purplish-brown, wavy lines across the outer part of the wings, a zigzag line near the base, and a few spots of the same color on the end of

the cell. The hind wing is shaded with purple next the body, with two curved, dark purple bands within the outer border. In the middle of the wing is a large, round, blue spot with a whitish centre, enclosed in a broad ring of brownish black. The females differ in having the fore wings suffused with purplish brown and the usual lines quite light. The cream-colored eggs, marked with orange and brown, are laid in clusters of thirty or more on the underside of the leaves, and hatch in about twelve days. The young caterpillars are one-eighth of an inch in length, of a reddish color, and covered with long bristles. They are social in their habits until half-grown, feeding and moving about in regular ranks, but when larger they separate, and wander about feeding alone. When mature they are about two inches and a half in length, of a delicate pale-green color, somewhat paler along the back, with a broad, dull-white stripe, margined with reddish lilac, on each side. They have several clusters of green branching spines, tipped with black, on each segment. These spines are very sharp, and when the insect is carelessly handled they sting severely, producing an irritation similar to that of a stinging nettle. After the caterpillars are done feeding they

FIG. 573. — *Tolype vellida*.FIG. 574. — *Eacles imperialis*.

descend to the ground, where they draw together a few dried leaves, within which they spin a cocoon of tough, gummy, brown silk, and remain in the pupa state during the winter. This species has quite a varied appetite, feeding freely on a large number of plants, such as apple, thorn, willow, elm, oak, corn, cotton, and clover.

The group of moths in this family, called Attaci, includes some of the largest as well as the most valuable silk-producing species.

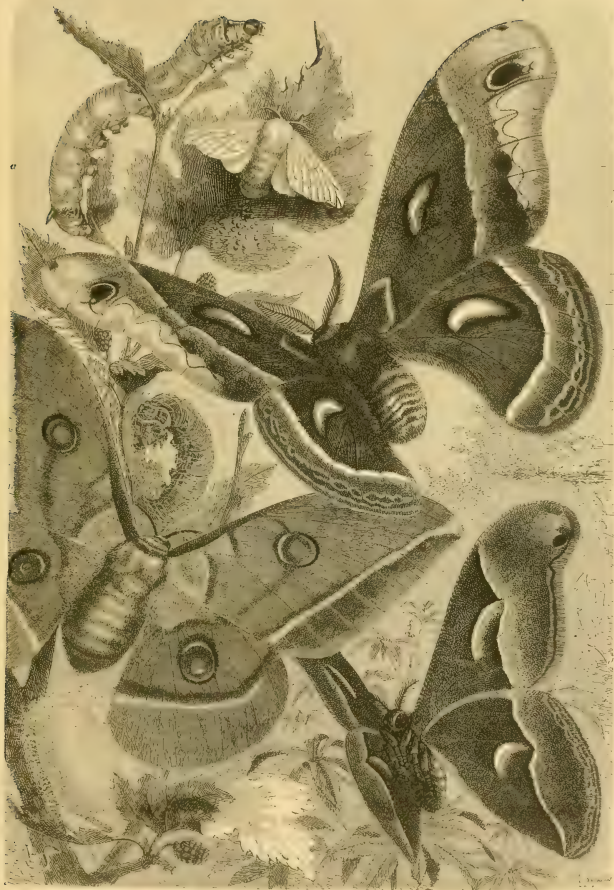
The Pernyi silk-worm, *Attacus pernyi*, an oak-feeding species, was first introduced into France from northern China in 1850; and it has since been brought to this country, where its cultivation gives much promise of success as a silk-producing moth. The brownish, globose eggs are said to hatch in eight or ten days after they are laid, and the young caterpillars are of a chocolate-brown color, with reddish tubercles, on which are reddish bristles. The color changes with each moult; and the mature caterpillar is of a dark green color, with a faint reddish line along each side. The head and feet

are light brown, with black spots, and the triangular anal mark is chocolate brown. The cocoon is suspended by a cord attached to the loose outer silk, which does not prevent its being reeled. The silk is yellowish gray, coarse, and brilliant. There are two broods in a year, the second remaining in the cocoon during the winter.

The moth expands nearly six inches, and is of a pale reddish yellow, varying somewhat in shades, with the inner half of the costa of the fore wings and the front of the thorax ashy gray. A pink or whitish line, with an inner edging of dark scales, crosses the outer part of all the wings, and a faint reddish line extends across the base. On the end of the cell in each wing is a circular eye-spot having a transparent centre, edged with black on the outside, but with white and red towards the base of the wing. The fore wings are more falcate in the males than in the females. In China this species is said to be reared in the open air in the wild state, and also under cover on branches of the trees, the ends of which are placed in water to keep them fresh. In this country they feed on oak, beech, and liquidamber.

The *Cecropia* silk-worm, *Platysamia cecropia*, which has a wide distribution in the United States, is one of our largest moths, expanding six inches or more. It has a most remarkable appetite, feeding on no less than fifty different species of plants, among which are the apple, plum, maple, elm, oak, beech, birch, willow, etc. The female lays from two to three hundred eggs, singly or in small clusters, on the underside of the leaves. These eggs, which are creamy white and striped with reddish, hatch in eight or ten days. The young caterpillars are black, with minute, black, hairy tubercles on the surface of their bodies. At each moult they change in color as well as in size; and, when mature, they are from three to four inches in length, of a pale green, or bluish-green color. The tubercles on the third and fourth segments are coral red, the others on the back are yellow, except those on the second and last segments, which, with those along the sides, are blue; and all are more or less armed with black bristles. When mature they crawl to some small branch or twig, on which they construct elongated, coarse, dull brown cocoons, in which they pass the winter. The wings of the moth are of a rich brown color, sprinkled with gray scales, with a large kidney-shaped spot, shaded more or less with red, and margined with black, near the middle of each wing. A red band, edged on the inside with white, crosses the wings a little beyond the middle. The outer edges of the wings are of a pale, silky brown, through which runs an irregular black line on the fore wings, and a double, broken band takes its place on the hind wings. The base of the fore wings is dull red, with a curved white and black line; and near their apex is a black eye-spot with a bluish crescent in it, and a shade of lilac above. This moth has not as yet been successfully cultivated for silk, because of the difficulty in reeling the cocoons.

The *ailanthus* silk-worm, *Philosamia cyathia*, of China, has been introduced into Europe and America, along with its food plant, *Ailanthus glandulosa*, and has readily adapted itself to the climate, so that it is now rather a common species in some localities, 'escaped from cultivation.' The female deposits about two hundred and fifty eggs, oval in form, cream-colored, and spotted with dark green or black particles. The young caterpillar is yellowish, with five longitudinal rows of black spots, and six black tubercles with white bristles on each segment; the head is also black. The mature caterpillar is about three inches long, of a light bluish-green color, with a yellowish head and blue tubercles, and presenting the appearance as shown in Fig. 575. When done feeding it draws a leaf partly together, within which it spins its cocoon; and, in a few weeks, the moth emerges. Those of the second brood remain in their cocoons on



SILK-WORM MOTHS.

a, *Bombyx mori*, eggs and larvæ. b, *Atherya pernyi*. c, *Samia cecropia*. d, *Samia cynthia*.

the trees during the winter. The perfect moth expands over four inches, and is of a "rusty yellow color, slightly inclining to green, marked with pale lilac and white." For culture in the open air, this promises better than any native species.

The American silk-worm, *Telæ polyphemus*, is, without doubt, our best native silk-producing species, although very satisfactory results have not as yet been obtained, either in rearing them or in reeling the silk. There is some reason to believe, however, that, by careful breeding and selecting, a race may be obtained after a series of generations, which will possess the desirable qualities. Each female lays from two to three hundred eggs, which are deposited on the under side of the leaves, and are about one-sixteenth of an inch in diameter, slightly convex on the top and bottom, the convex portions whitish, and the nearly cylindrical sides brown. These hatch in from ten

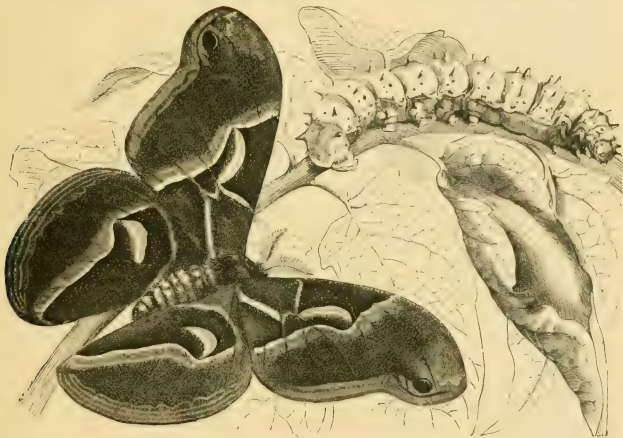


FIG. 555. — *Phibosamia cytharæ*, ailanthus silk-worm.

to twelve days. The caterpillar feeds on the leaves of oak, elm, etc, and when full-grown is over three inches in length, of a light-green color, with seven oblique yellow lines on each side, and the tubercles on the segments orange with a silvery spot on the middle. A few hairs arise from these tubercles. The last segment is bordered by a purplish brown V-shaped mark. After the caterpillar has finished eating, it draws together a few leaves within which it spins its whitish, oval cocoon, which often falls to the ground, where the insect remains during the winter in the pupa state.

The experiments of Mr. Trouvelot prove that this insect may be bred in the open air or in captivity, and that the cocoons may be reeled, though this is rather difficult because of the hard matter which holds them together. The moths, before emerging from the cocoons, discharge a quantity of fluid matter which moistens and softens the silk at the end from which they are to escape, so that they can more easily work their

way out, after which they climb upon some object and allow their wings to develop and harden before attempting to fly. The perfect moth expands from five to six inches. The wings are of a rich ochre-yellow color, sometimes inclining to pale gray or cream color, and sometimes they are almost brown. A whitish band margined with red crosses the base of the wing, and a stripe of pale purplish white, bordered within with one of brown, crosses the wings towards the outer margin; and near the middle of each wing is a transparent eye-spot with a slender line across the centre. Those on the fore wings are the largest, and nearly round, margined with yellow, and edged outside with black. Those on the hind wings are margined with yellow, with a line of black, edged with blue above, and the whole set in a large, oval patch of rich brownish black.

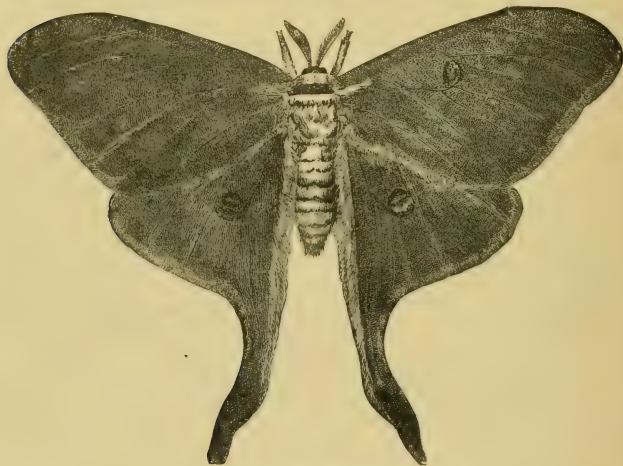


FIG. 576. — *Actias luna*, luna moth.

The luna moth, *Actias luna*, is unrivalled for loveliness and beauty by any in its tribe. The wings expand about five inches, and are of a delicate light-green color, the hinder ones terminating in a tail an inch and a half or more in length. All the wings are edged with pale ochre. Along the front edge of the fore wings runs a broad purplish stripe which extends across the thorax. There is an eye-spot on the end of the cell of each wing, with a transparent, elliptical centre and encircled by rings of white, yellow, blue, and black. The body is white, with the exception of the brown stripe across the thorax.

The eggs are smooth, rounded and somewhat flattened, of a dark-brown or chocolate color, and hatch in about twelve days. The young caterpillars are black with yellowish spots on the segments, and numerous yellow hairs. They feed on hickory,

beech, oak, walnut, maple, willow, and plum. The full-grown caterpillar is not more than two inches in length when at rest, and three when in motion, pale blue-green with a pearl-colored head. It has a pale yellow stripe along each side of the body, and a transverse yellow line between the segments of the back. There are five or six small pearly tubercles on each segment, tinged with purple or red, and having a few hairs. When mature it descends to the ground, when it draws together a few leaves, and spins an oval, very compact and strong cocoon of white or yellowish silk. It has been said that the cocoons are spun in the trees, and fall to the ground with the leaves in the autumn. They remain in this state all winter, and emerge the next summer, there being but one brood in a year. The silk from the cocoon of this moth is of but little value, from the fact that it has never been reeled, and probably never can be; yet it would doubtless be of some value as carded silk.

The mulberry silk-worm, *Bombyx mori*, has been, without doubt, the most useful to mankind of all insects, furnishing employment to vast numbers of people in different countries in raising the worms and obtaining the cocoons, and to others in manufacturing the silk into such varied and beautiful fabrics as are offered both for our comfort and adornment. This species has been cultivated in China, for the silk, from time immemorial; and the caterpillar in its wild state is now unknown, though it may yet be found in that country. This insect was not introduced into Europe until A. D. 550, and then only by stealth; for the inhabitants of China and southern Asia would not permit them to be taken out of the country. Two monks are said to have brought away the eggs concealed in their canes, and introduced them into Constantinople, from which place they were later taken into other parts of southern Europe. It was not till the latter part of the sixteenth century, or early in the seventeenth, that an attempt was made to introduce this silk-worm into America where it has been cultivated with varying success down to the present time. Aside from its natural food plant, the mulberry, it thrives well in this country on the leaves of Osage orange, thus making it possible to cultivate them in portions of the country where it otherwise would be impracticable. This insect has been cultivated so long, and carried by man to so many different countries, and reared under such diverse circumstances, that it may be considered not only completely domesticated, but so many different races have been obtained, that we are really in doubt what the exact characteristics of the original stock may have been.

The eggs are nearly round, yellow when first laid, changing to a slate or gray color, and fastened by an adhesive substance which the moth secretes at the time the eggs are laid. Each female lays three hundred or more eggs. The young caterpillars are black or dark gray, and clothed with long, stiff hairs which arise from pale tubercles



FIG. 577. — Anatomy of silk-worm.

on the segments. They grow paler with each moult, and, after feeding about a month, reach maturity, and lose their tubercles, except the one on the eleventh segment, which takes the form of a curved, tapering horn, much like that on many of the Sphingidæ. The caterpillars are then about two inches long, of a dull-bluish color, with small heads, and having the surfaces of the three segments following, thrown up into wrinkles. On the top of the sixth segment is a pair of darker-blue lunate marks. The cocoons which they spin have an outer covering of loose or floss silk, within which the silk is more dense. They are oval in form, and pale yellow, or sometimes pure white, cream colored, green or rose colored. The insects remain in the pupa state about three weeks, at the end of which time they emerge, the sexes pair, and the females lay their eggs, after which they die. The moths expand a little more than an inch, and are cream colored, with two more or less distinct lines across each fore wing. Neither sex flies, but the males are more active than the females.

The hickory tussock-moth, *Halesilota carya*, is a common species throughout the Atlantic states and Canada, at times becoming so abundant as to do a great amount of damage. They are not limited as to food plants, for they seem to thrive equally well on the leaves of hickory, walnut, ash, elm, butternut, sumac, beech, birch, alder, apple, and plum. When the caterpillars are mature, they leave the trees, and in some protected place, make their thin oval cocoons which are composed of their hairs mingled with silk, which they spin. Here they change to pupæ, and remain till the following summer, when the moths emerge. The moths expand about two inches, the fore wings being of a light ochre-yellow color, dusted with dark brown, especially along the veins, with five transverse rows of silvery white spots. The hind wings are much shorter than the fore wings, and of a paler yellow.

The group of Arctians possesses many beautiful forms, possibly the handsomest of our species being *Arctia virgo*. This moth spreads about two and a half inches, its fore wings are salmon or flesh color, marked with broad black stripes, while the hind wings are vermilion, ornamented with black dots.

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Arctia nais is widely distributed in this country, from the Gulf of Mexico to Canada and from the Atlantic to the Pacific. It is so extremely variable in its markings that it has been described under nine different names, and Drury himself gave names to at least two of the forms. It expands an inch and a half or more, and the wings are pale yellow. Sometimes a tinge of red is observed on the base of the hind wings and sides of the body. There are two wide black stripes on the fore wings, the hinder one extending from the base nearly to the anal angle; the other, from the base to the end of the cell. On the outer part of the wings are about four triangular and quadrate black spots; but there is great variation in the amount of black, the spots sometimes being more or less fused together. The hind wings have several black spots near the outer margin; and in some examples these are so large as to run together, leaving only a little of the ground color at the base of the wings.

The eggs, which are laid in clusters of thirty or more on the strawberry and dandelion, are somewhat conical, smooth, and white, and hatch in five or six days. The cater-



FIG. 578. — *Halesilota carya*.



FIG. 579. — *Arctia nais*.

pillars reach maturity after five moults, being at that time nearly one inch and three-fourths in length, of a black color, with a yellow line along the middle of the back. There are ten tubercles on each segment, with a cluster of hairs arising from each. The hairs on the back of the segments are black, but on the sides they are brown. The pupa is three-fourths of an inch long, smooth, shining black, and enclosed in a loose cocoon, which the insect spins in some protected place.

Nola sorghiella is a troublesome pest, which infests the heads of sorghum in the gulf states, spinning its silken threads over and among the seeds in such a manner as to form a compact mass in which the whitish excrements of the caterpillars are scattered. These caterpillars form numerous delicate tubes through which they pass from one seed to another, feeding more especially on the germ, but sometimes consuming nearly the entire seed. They are very active when disturbed, and at maturity descend to the ground, where they spin a fine, delicate cocoon covered with particles of wood, bark, or other convenient material. The moths, according to Professor Riley, emerge late in July or early in August, and expand a little less than half an inch. They are of a silvery-white color, with a row of three tufts of scales below the costa on the fore wing, and a yellowish-brown, curved band across the wing towards the outer margin. The mature caterpillar is half an inch long, of a yellowish or light greenish yellow color, with a small, yellowish head. It has a sulphur-yellow line along the middle of the back, and a rather broad, brownish, longitudinal stripe on each side. Each segment has a transverse row of six tubercles with short, stiff, brownish-tipped, yellow bristles, and a similar tubercle at the base of each leg.

The family ZYGENIDÆ comprises those moths which have the head of moderate size, and free from the thorax, with ocelli present. In the typical genera the antennæ are simple, and slightly enlarged in the middle, or partially clavate towards the tips. The thorax is moderately stout, and longer than broad. The abdomen is short and thick, generally twice the length of the thorax. The wings are long and narrow, though often triangular, and the cell is so long that the nervules are shorter than in the allied families. The costa of the fore wing is comparatively straight, the apex much rounded, and the outer edge full, and half or two-thirds as long as the hinder edge. The hind wings are generally one-half longer than wide, though sometimes the length is twice the width. The legs are rather stout, but well proportioned, and thickly scaled in the typical species; but in one group they are armed with long, sharp spines, and the femora are hairy, while the fore tibiae are densely pilose. The scales in this family are fine, powdery, and scattered thinly over the surface, often leaving naked spots on the wings. Some of the species fly in the bright sunshine, others by night.

Dr. Packard includes *Castaia* and its allies of South America, and *Synemon* with its allies of the Australian region, in this family. These last insects resemble the butterflies in many respects; but in their general structure, habits, and early stages, so far as known, they are more nearly allied to the typical Zygenidæ than to any other family. The caterpillars in this family differ considerably, some being naked, and others clothed with hair; and while some species spin a dense cocoon, others make none at all. Some spend the winter in the pupa, and others hibernate in the caterpillar state. The Zygenidæ are most abundant in tropical and warm temperate countries, very few extending to the Arctic regions.

Harrisina americana is distributed throughout the middle part of the United States, from east to west. The wings, which are long and narrow, expand nearly an

inch. The entire insect is greenish black, with the exception of the prothorax, which is orange yellow. The caterpillars are gregarious, living and feeding together in considerable numbers on the same leaf.



FIG. 580. — *Harrisina americana*, larva and adult.

sides and black on the back. It feeds upon the lichens on stones in shady places, and undergoes its transformations in a thin silky cocoon.

The beautiful wood-nymph, *Eudryas grata*, expands about an inch and three-quarters. Its fore wings are creamy white with a broad stripe along the costa, from the base to the middle, and a broad band along the outer margin, of a deep purplish-brown color. The band is olive green on the inner edge, and has a slender white wavy line along the outer margin. Near the middle of the wing are two brown spots, one of which is round, the other, kidney-shaped. At the centre of the hind margin is a large triangular olive-green spot. The hind wings are yellow, with a purplish-brown band along the outer margin, on which there is a white line. The thorax is white, with a central longitudinal stripe of black and pearl-colored scales. The head is black, and the abdomen yellow, with a row of black spots on the upper surface. The fore tibiae are densely clothed with long hair-like scales, giving them a singular snuff-like appearance. This beautiful moth deposits its peculiar eggs, singly or in small clusters, on the under side of the leaves. These eggs are circular, very flat, of a greenish-yellow color, and beautifully sculptured with radiating ribs and fine cross lines. When first hatched the caterpillars are greenish yellow dotted with black. They eat small holes through the leaves;



FIG. 582. — *Eudryas grata*.

They are hatched from eggs laid in clusters of twenty or more on the under side of the leaves. When fully grown they are a little more than half an inch long, of a yellow color, with a transverse row of black velvety tufts on each segment, and a few hairs on each extremity of the body. They feed on the leaves of the grape and the common creeper, *Ampelopsis quinquefolia*.

Lycomorpha pholus flies only in the day time, and is remarkable for its long narrow wings, which expand a little over an inch. The entire insect is bluish black, with the exception of the shoulder covers, and the basal half of all the wings, which are orange colored. Harris states that the caterpillar is pale green, with yellowish spots running into green. The head is black and covered with a few short, whitish hairs; while the body is clothed with rather long hairs, which are white on the



FIG. 581. *Lycomorpha pholus*.

and, when at rest, they throw the hind segments of the body forward over those in front, making a curious sort of a loop.

The mature caterpillars are about an inch and a half in length, tapering slightly towards the head and becoming thickened towards the posterior extremity. The head is orange, dotted with black, and the body is pale bluish, crossed by bands of orange and many fine black lines. These caterpillars much resemble those of *Allypia octomaculata*, but may be distinguished by having only six transverse black lines on each segment, while *Allypia* has eight. When the caterpillars have reached maturity, they descend into the ground, and transform into dark-brown pupæ. This species feeds upon the leaves of grape, Virginia creeper, and occasionally upon the hop.

The eight-spotted forester (*Allypia octomaculata*) is quite widely distributed in this country, and in many places is quite a common species. This moth expands about an inch and a quarter, and is of a deep bluish-black color, with two large pale-yellow spots on each fore wing, and two white spots on each of the hind wings. The shoulder covers are yellow, and the legs are marked with orange.



FIG. 383. *Allypia octomaculata* and larva.

The full-grown caterpillar, which is a little over an inch long, has a bluish tinge, owing, however, to an optical phenomenon, from the contrast of the white with the transverse black lines. The young caterpillar is paler, and has less distinct markings. It feeds on the under-side of the leaves, and lets itself down by a thread of silk when disturbed; but, after the danger has passed, it ascends again by the same means. When mature, the caterpillar descends to the ground, and changes to a pupa in an earthen cell, which it forms near the surface of the ground. There are two broods of this insect in a year, though, perhaps, only one in the more northern limits of its distribution. It feeds upon the leaves of the grape.

The EGERIIDE are insects of rather small size which fly in the hot sunshine, and somewhat resemble the wasps while on the wing. They have spindle-shaped antennæ, terminated by a small silky tuft. The palpi are stout, curved up in front of the head, the third joint being slim and naked. The legs are stout, and covered with scales or hairs; and the fore tibiæ have one spur (tibial epiphysis), the middle tibiæ, a pair of unequal spurs at the end; and the hind tibiæ, two pairs, one at the end and one in the middle. At the end of the abdomen is a fan-like tuft of scales; and the long narrow wings are covered with scales in some species, but in others they are transparent, except on the veins, along the margins, and a band across the fore wings at the end of the cell. The caterpillars, which are whitish, with dark-colored heads and a few scattered hairs over their bodies, are borers in the stems of trees and shrubs; and, when present in large numbers, they destroy the life of the plants which they have attacked. These beautiful little moths are lovely objects as they rest upon the surface of plants, the bright sun reflecting the light from their metallic-blue colors, which contrast with their gay markings of crimson, orange, or white. Not far from two hundred and fifty species have already been described.

The peach-tree borer (*Saundersia exilis*) is an insect far too common in the peach-growing regions of this country. Its wings expand about an inch, though they vary much in size. The head, thorax, and abdomen are of a steel-blue color, with various yellow markings. The wings are glassy and transparent, with the veins, margins, and

fringes steel-blue, the fore wings having a band across them beyond the middle. The females have the fore wings opaque, and of the same color as the body. The dull yellow, smooth, oval eggs are deposited on the bark of peach trees, near the surface of the ground. The caterpillars, when hatching, work downward in the bark of the root; and, when the tree is badly infested, the soft sapwood is also more or less eaten. They pass the winter in this state, completing their development the next spring, and the perfect insects emerge in the summer.



FIG. 584. — *Samnius eritosa*, peach-tree borer.

Aegeria pictipes attacks the trunks of plum trees, and is similar to the last-named species in its habits. The imported currant-borer, *Aegeria tipuliformis*, is a common species both in Europe and this country, and is quite injurious to currant and gooseberry bushes.

The Sphinx moths (SPHINGIDÆ) take their name from the curious habit which their caterpillars have of raising the anterior segments of their bodies, and remaining motionless in this position for some time, thus bearing a fancied resemblance to the fabled Sphinx. They are sometimes called the hawk moths, because of the strength and velocity of their flight; and they are also called humming-bird moths, because they poise on the wing before the flowers, while drawing up the nectar, after the manner of humming-birds. They have stout bodies, and long, narrow wings, the anterior ones being much longer, and generally more pointed, than the posterior ones, the latter being furnished with a frenulum or bristle.



FIG. 585. — Larva of *Phlegethontius carolina*.

One group has the middle of the wings transparent, and on this account are called clear-wings. The head is well developed, the eyes large and hemispherical, but no ocelli are present. The tongue is very short in a few of the species, in others it is well developed and as long as the body, while in still others it is much longer when uncoiled, and is used to draw nectar from the long tubes of certain species of orchids; and the peculiar pollen-masses of these plants are often found adhering to the eyes of the moths, and are carried from one plant to another, thus aiding in the cross-fertilization of the plants. The antennae, which are very characteristic in this family, are fusiform or spindle-shaped, the end sometimes being curved into a hook, with a ciliated seta or bristle from the apex. In the males they have two rows of cilia, but are nearly simple in the females. The abdomen is cylindrical, conical at the end, and the legs are usually long and strong. The fore tarsus has a long single spur (tibial epiphysis) on the inner surface, the middle a terminal pair, and the hind tarsus has a pair on the middle and another at the end.



FIG. 586. — Pupa of tobacco-worm.

The eggs of these moths are deposited singly on their food plants. The caterpillars have naked, cylindrical bodies, sometimes smooth, but frequently more or less granulated over the surface. The majority of them are of some shade of green, with various markings, often oblique bands or stripes along the sides. On the top of the twelfth segment is placed a rigid spine which curves backward, and is called the caudal horn. When this is absent, its place is indicated by a tubercle. When the caterpillars are mature they descend into the ground where they make rude cocoons

or cells in which they change to pupæ, which are quite remarkable in some species, because of the peculiar tongue-case which stands off from the body like a jug-handle. The pupæ remain in the ground all winter, and the moths emerge the following summer, though occasionally a specimen remains in the pupal state till the second summer. Not far from five hundred species have already been described in this family.

The Thyſe clear-wing, *Henaris thyſe*, is a very common American species, having an expanse of wings of about two inches. The head and thorax are dark green mixed with brown; and the abdomen is yellowish brown at the base, reddish brown in the middle, and dull yellowish brown with ferruginous patches at the extremity. The fore wings are transparent, with blackish veins and a ferruginous spot near the apex. The costa, outer-border, basal portion of the wing, and an oblique stripe across the end of the cell are covered with dark-brown scales, making these portions of the wing opaque. The hind wings are transparent, with blackish veins.

The outer border is dark brown, with a bright ferruginous base. The caterpillar is an inch and three-fourths long, of a clear green color, lighter on the back. The central stripe along the back is bordered by two white lines, and a white or yellowish-green



FIG. 557. — *Henaris thyſe*.



FIG. 558. — *Euryx myron* and larva.

lateral stripe extends from the second segment to the caudal horn which is light blue tipped with yellow, and granulated with white on the sides. Before transforming to a pupa, it changes considerably in color. This species feeds on the leaves of snow-ball (*Viburnum opulus*), and completes its transformations within an imperfect cocoon composed of a few leaves drawn together by silken threads, in which it passes the winter. The moths fly only in the hot sunshine in the middle of the day, where they may be seen hovering over flowers in company with other species of clear-wings, and also with humble-bees, which they somewhat resemble while on the wing.

The green grape-vine sphinx (*Euryx myron*) is very generally distributed through the United States. The wings expand about two inches and a half. The head and thorax are dull dark green, and the fore wings are dark olive green, crossed by bands and streaks of greenish gray, shaded on the outer margin with the same color. The hind wings are dull red, with a patch of greenish gray next the body, shading gradually into the surrounding color.

The eggs, which are deposited singly, or in groups of two or three on the under side of the leaves, are nearly round, smooth, and of a pale yellowish-green color, changing to reddish before hatching, which occurs in five or six days.

The young caterpillar is one-fifth of an inch long when first hatched, of a pale green color, with quite a large head. The caudal horn is black, and half as long as the body. As the caterpillar increases in size, the horn becomes relatively shorter;

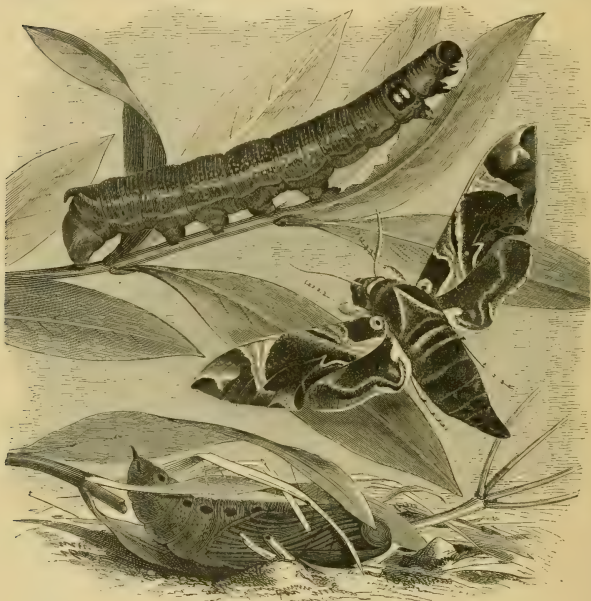


FIG. 589. — *Deilephila nerii*, oleander sphinx.

and, at each moult, the color and markings of the body change more or less. When mature, the caterpillar is about two inches long, with a small greenish head dotted with yellow, and a pale yellow stripe down each side. The body is of a darker green than the head, and is covered with small yellow granulations. There are seven oblique stripes on each side, composed of yellow granulations, edged behind with dark green. A white stripe, also edged with green, extends along each side, from near the head to the caudal horn. A row of seven spots, varying in color from red to pale

lilac, each set in a pale-yellow patch, extends along the middle of the back. The caudal horn is reddish or bluish green, granulated with black in front. Much variation of color occurs among these caterpillars. Instead of green they are sometimes of a reddish pink, with markings of darker shades of red or brown. When mature they descend to the ground, where they draw together a few leaves or other material, with threads of silk; and within these they transform to pupæ.

There are two broods of this insect each year, and they pass the winter in the pupa state. They feed on the leaves of the grape.

The oleander sphinx (*Deilephila neri*) belongs to Africa and southern Asia, but extends into Europe even as far as the southern shores of the Baltic and to the British Isles. This species is probably the most richly adorned and magnificent of all the members of this family. The fore wings expand four inches or more, and are of a



FIG. 596. — *Phlegethontius carolina*, tobacco-worm moth.

pale rosy-gray color, with large irregular blotches of dull green more or less intersected with wavy whitish streaks. The hind wings are purplish brown at the base, shading into dull green at the margin, with a single curved whitish line a little beyond the middle. The mature caterpillar is green or yellow, with two large ocellated spots on the sides of the fourth segments, and a longitudinal white stripe on each side, with numerous small white dots on all the segments from the sixth to the twelfth. The caudal horn is of an orange-yellow color, short, blunt, and curved downwards. It feeds on the leaves of *Oleander* and *Vinea*.

The tobacco-worm moth (*Phlegethontius carolina*) occurs in the United States, Mexico, and South America. The wings expand nearly four inches. The head, thorax, and fore wings are brownish gray, with a white spot at the base of the wing and one at the end of the cell. The wings are crossed by lighter and darker shades and black lines. The hind wings are gray with a black spot at the base, a double black band across the middle, and a broad marginal stripe of blackish gray. The abdomen is blackish gray, with a double row of white spots along the back, and five

nearly round orange-yellow spots on each side, with five black bands between, and intermediate white spots below. The caterpillar, Fig. 585, is dark green, a little paler along the back, with whitish dots. There are seven oblique white stripes on each side, bordered above with dark brown. The caudal horn is of a bluish color, whitish on the sides, and studded with black thorns, or sometimes the whole horn is black. The whole upper surface is granulated, and the breathing pores (stigmata), along the sides, are edged with blue, with a yellow point above and below. When mature it descends into the ground, and forms an imperfect cocoon-like cell of earth in which it changes to a dark reddish-brown pupa, with a curved tongue-case. This species feeds on the leaves of tomato and tobacco, causing a great amount of damage when abundant.



FIG. 591. — *Paonias excecatus*.

The blind-eyed sphinx (*Paonias excecatus*) is distributed throughout the Atlantic states from Canada southward. The wings expand from three and a quarter to three and a half inches. The body is fawn colored, with a chestnut stripe on the middle of the thorax, and a dark line along the abdomen. The fore wings are fawn colored, clouded and striped

with brown. The hind wings are rose colored in the middle, with a brownish patch on the apex, and a black spot with a pale-blue centre near the anal angle. The mature caterpillar is about two inches and a half long, with an apple-green body, paler on the back, but deeper in color along the sides; and the skin is roughened with numerous white-tipped granulations. There are seven oblique stripes on each side, of a pale-yellow color, the last one of a brighter yellow than the others, and extending to the base of the caudal horn, which is of a bluish-green color. These caterpillars feed on the leaves of apple, plum, wild cherry, elm, etc.; and, when mature, they leave the trees and bury themselves in the ground where they transform in earth-cases, to brown-colored pupae, in which state they pass the winter. They are so subject to the attacks of parasitic Hymenoptera that they are seldom abundant.

The death's head moth (*Acherontia atropos*), which is widely spread over Africa, Asia, Central and southern Europe, is one of the largest species of this family, expanding from four to five inches, or even more. The fore wings are blackish brown, with indistinct tawny markings and wavy transverse lines of black, and a conspicuous white spot near the middle. The hind wings are yellow with a narrow black band across the middle, and a wider one near the outer margin. The thorax is blackish brown, having a pale-yellowish mark on the middle which resembles a human skull, from which it has received its common name. The abdomen is yellow, banded with black; and it also has a broad bluish-black central stripe. The caterpillars when mature are from five to six inches long, of a bright lemon-yellow color, with seven oblique violet stripes on each side, and a row of triangular blue spots along the back. The whole surface is granulated, and sprinkled with black. The caudal horn is very peculiar and characteristic; for it first inclines backward, and then turns up and curves forward. They feed on the leaves of potato, tomato, and a variety of other plants. When they have finished feeding they burrow into the ground, and form oval cocoons in which they transform into pupae. The moth, when frightened, makes a peculiar

sound similar to the squeaking of a mouse; but the means by which this noise is made no one has definitely ascertained. This insect has been regarded in some countries by the superstitious as an evil omen. Its large size, powerful flight, the weird skull-like mark on the thorax, and the "peculiar, plaintive sound" which it emits, have all



FIG. 592. — *Acherontia atropos*, death's head moth.

conspired to render it an object of alarm to the ignorant; and, on the Isle of France, the opinion once prevailed among the common people that the dust cast from its wings in flying through a room would produce blindness if it happened to fall on the eyes.

C. II. FERNALD.

SUB-ORDER II. — RHOPALOCERA.

The line drawn between the butterflies and the moths is a rather arbitrary one, the most prominent difference being that, in the group now under discussion, the antennæ are always knobbed at the extremity, though in some forms they are nearly as filiform as in some moths, while, on the other hand, some of the moths have these organs almost club-shaped. None of the butterflies have the frenulum, a bristle uniting the two wings, as do many moths. The eggs of butterflies are usually more complicated and ornamental in their outline than those of the moths. The larvæ are all external feeders, and do not spin cocoons, but transform into the chrysalis state by suspending themselves, either by the tail or by a silken thread or band around the centre of the body, while the perfect insects invariably fly by day, and are hence called Diurnals. Not, however, that all the moths fly by night. Many of them are day-fliers, and a few families wander abroad



FIG. 593. — Head of butterfly.

only at twilight. The colors of the butterflies are generally brighter and more showy than those of the moths, though even this can by no means be taken as a rule, the magnificent ornamentation of such tropical forms as *Urania rhiphaeus*, and many of the Indian and African Glaucopidae, being as grand and striking as any that can be presented by the butterflies themselves. But with all these apparent contradictions, and although some of the lower families of the Diurnals (e.g., the Hesperidae) closely approach the moths, while certain moths (e.g., *Castnia*, *Syne-mon*, etc.) may readily, until their habits and life history are studied, be mistaken for butterflies. The separation can always be made by the practised eye; and it will therefore be sufficient for our present purpose to call brief attention to these associations of structure, and, without entering more deeply into the subject, to state that the Diurnal Lepidoptera are restricted to those genera which, in addition to the characters mentioned above, have the wings always elevated in repose, a habit which obtains with none of the moths, though it is true that many, though not all Hesperians, rest with the fore pair erect, the hinder being spread out flatly upon the supporting surface. Bearing these facts in mind, and remembering that nature delights in seeming anomalies, and that her creations, as they appear to us now, can hardly be dealt with in a direct line of relationship, we shall readily understand the creatures with which we have now to deal.

The earliest stage of the butterfly, as of all insects, is the egg. These are laid



FIG. 594. — Lepidopterous eggs, enlarged.

with remarkable instinct by the parent, inserted either on or near the plant which is to become the future food of the larva, and are usually deposited singly, or, at least, very rarely in masses. They are of various shapes, mostly, however, inclining to spherical or cone-shape, with a flattened base; are very seldom quite smooth, but often marked with ridges or granulations, giving a lace-like appearance to the surface. Some have raised points or cones, and a few species bear small and insignificant spines. The period occupied in the egg stage varies considerably, some species producing

the larva in five or six days, while others remain nearly a month, and not a few pass entirely through the winter in that condition.

The larvæ begin to feed immediately on their exclusion from the egg, and rapidly increase in growth. They cast their skins four, five, or, according to some observers, in a few species, not less than six or even eight times, each moult producing a greater or less change in the appearance of the caterpillar, and adding greatly to its size. The body is composed of twelve segments exclusive of the head, the three anterior of which bear the true legs, and the sixth, seventh, eighth, and ninth the abdominal or prolegs, the anal segment being provided with claspers or modified legs, making in all eight pairs, the fourth, fifth, tenth, and eleventh segments being devoid of these organs. The body is furnished with various forms and arrangements of hairs, spines, and tubercles, and the difference in color and in the disposal of the markings affords a good guide in distinguishing many closely allied species. In the Papilionidae the caterpillar is furnished on the upper and forward part of the second segment with a pair of retractile horns which, in many species, secrete a strongly smelling fluid,

probably used as a means of defence against parasitic and other enemies. The head of the Lyceiid larva is also retractile into the folds of the second segment, so that it is hardly visible from above; while Mr. W. H. Edwards has observed that they are furnished with retractile spines giving out a honey-like fluid, especially grateful to certain species of ants. The Papilionidae have the head also partially concealed; but in the Nymphalidae and other groups it is at all times free and extended. In the Hesperidae the second segment is usually greatly constricted, giving the head an almost monstrous appearance. In most cases the caterpillars of the butterflies move rapidly from place to place; but in the Lyceenidae they are onisciform, or shaped somewhat like the common wood-louse, the prolegs being hardly visible, and the animal seeming to glide rather than walk over the surface of its resting-place. The forms and armature of the larvæ are very variable, their bodies being in some cases almost naked, and in others covered with hard and complicated spines, or with corrugations, foveæ, or tubercles of an almost endless variety of pattern. No special law can be laid down for the duration of the larval stage; but from fifteen to thirty days may be regarded as the usual period, though many species remain longer than this, and not a few pass over the winter in their caterpillar condition.



FIG. 595. — Larva of *Lyceus*.

To the stage succeeding the larva, the various terms *aurelia*, pupa, and *chrysalis* have been applied, the last being that now generally used by lepidopterists as applied to the Diurnals, the word pupa being given to the corresponding state in the moths, or those insects which spin cocoons. The name *aurelia* has now become obsolete, and was never more than of partial application, having been used by the older naturalists from the fact that many of the chrysalides of butterflies are marked with golden spots and blotches (*aurum*, gold) giving rise to the term.

The chrysalis, properly so called, may be said to consist of a series of more or less horny and variously-formed integuments, covering up and concealing the future external organs of the perfect insect. In the group we are discussing, there is a tendency towards a general outline as regards the form, which is longer than broad, thickest a little above the middle, and tapering somewhat abruptly to the posterior extremity. Some chrysalides are smooth and rounded, without angles; others are armed with long and sharp spines; others bear large thoracic or abdominal protuberances, while some are so grotesque in appearance as to be indescribable in familiar words. The position of rest while undergoing the change to the imago condition is a question of considerable interest, having a most important bearing upon the classification of the families, one group suspending themselves by the tail, and another by a girth around the body. The late Dr. Boisduval very happily distinguished these as the *Suspensi* and the *Succincti*. To the former belong the great group of the Nymphalidae (which is by far the most numerous over the world in point of individuals, if not of species), and to the latter the swallow-tailed butterflies, the garden whites, and the common yellow species (*Colias*). In the *Succincti* the head is usually directed upwards, while the Lyceenidae generally fasten themselves longitudinally upon the leaf or stem of a plant, and the Hesperidae fold themselves up in a leaf, with silken bands around the body, thus showing their close relationship to the moths. A great deal of discussion has arisen among



FIG. 596. — Chrysalis of *Danais* (*Suspensi*).



FIG. 507. — Chrysalis of *Papilio* (Succinct).

systematists as to the value of these peculiarities of the chrysalis in the classification of the butterflies, many deeming the Papilionidæ, from their superior size, the possession of four distinct branches to the median nerve of the front wings, and above all the development of the osmateria or scent-organs, to be worthy of the highest rank in the beautiful army of the Diurnæ; while others hold that the suspension of the chrysalis by the tail is evidence of a more advanced condition, the animal having in its development passed beyond the stage of the girth period, thus claiming that "the Suspensi outrank the Succincti, as the pupa is higher than the larva." Without presuming to settle this vexed question, it is but fair to state that the majority of lepidopterists in Europe and this country favor the latter view, and the able and almost exhaustive "Catalogue of Diurnal Lepidoptera," by Mr. W. F. Kirby of the British Museum, is based upon it, the series therein commencing with the Nymphalidæ, the Papilionidæ being degraded to a position a little in advance of the Hesperidæ. Giving no special adherence to either of these methods, the plan followed in the present paper will be the opposite of Mr. Kirby's arrangement; as Mr. W. H. Edwards, who has published the most complete catalogue of the butterflies of the United States, has adhered to the older method, and for the convenience of the students of our Lepidoptera, it is best to have some harmonious action, thus avoiding troublesome complications. The duration of the chrysalis, as of all other stages of insect life, is very variable, largely dependent upon climatic and other influences, but it may be said to average about 20 days. Many of these species that are double-brooded go through the winter, however, in this state.

When the hour of final transformation comes, the sutures of the thorax give way to the pressure from within, the rupture first taking place in the central division. This is followed by other fissures in the sides, an opening is formed, and the imago or perfect insect, with soft, wet, and undeveloped wings, crawls up the stem of a plant or the trunk of a tree, and, inflating its wings by gentle motion, causes them to expand in a few hours, and is enabled to soar away and enjoy to the full its brief but beautiful existence.

The perfect stage of the butterfly is so different from those which had preceded it, that it is necessary to speak of a few of its characters. The head "is composed of three well-marked pieces, viz., the occiput, or basal piece, which lies behind the ocelli; the epicranium, lying behind the insertion of the antennæ, and carrying the eyes and ocelli; and the clypeus which constitutes the front of the head. The labium or upper lip is small and often concealed by the clypeus, which is larger in the Lepidoptera than in all other insects, its size being quite distinctive of the order. The labium or lower lip is small, short, and triangular, and the mentum is nearly obsolete. The labial palpi are fully developed, sometimes rudimentary, and consists of from one to three joints, the terminal being small and pointed. They are renewed in front of the head, on each side of the spiral tongue, and are covered with hairs, their function as touchers or feelers, seeming to be lost. The mandibles are rudimentary, consisting of a pair of horny tubercles, partly concealed by the front edge of the clypeus. The maxillæ, on the other hand, are remarkably developed." The head is also furnished with two organs of smell called the antennæ, with a long tubular tongue for extracting the honey from flowers, which, when at rest, is rolled up in watch-spring form between the palpi; with a very beautiful and highly specialized pair of complex eyes,

as well as three ocelli, or simple eyes. To the thorax, or the portion of the body corresponding to the three anterior segments of the larva, bearing the three pairs of true legs, are now attached the more complicated legs of the mature insect, as well as two pairs of broadly expanded wings, traversed by a network of muscular veins, and covered by scales of feather-like form, of various sizes and colors. In one group, the *Nymphalidae*, the fore pair of legs are aborted, while in other groups they are developed to a remarkable extent. The nerves traversing the wing are modelled after one general pattern, though differing in detail, the central portion of each wing being

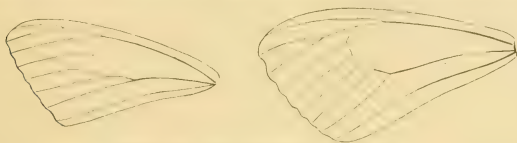


FIG. 598. — Wings, with discoidal cell opened and closed.

largely unoccupied by the nervules, and comprising the space known as the discoidal cell. In some families this cell is open in the lower pair of wings, in others it is closed by a cross nerve, thus affording a strong character for the division of the several groups, which will be hereafter attended to. The abdomen is only moderate in size in the butterflies, and is composed of six or seven segments, for the most part densely clothed with hair. The legs, which, as we have seen, are attached to the thorax, are composed of nine joints or pieces, the coxa, trochanter, femur, tibia, and five-jointed tarsus. There is in the butterflies always a long-pointed spur at the junction of the tibia with the tarsus, and the latter is terminated by two sharp claws. Any extraordinary development of the legs of butterflies tends towards that of length rather than of thickness; as the creatures do not walk, but fly, and their legs are used chiefly as organs of prehension.

The first great group, the *HESPERIDE* of authors, contains, according to Kirby, fifty-two genera, and about eight hundred species, in which “the six feet are of uniform size in both sexes; the hind tibiae have a pair of spurs at the apex, and generally another pair near the middle of the limb, a character found in none of the preceding butterflies; the hind wings are generally horizontal during repose, and in some species all the wings are placed in this manner. The antennae are wide apart at the base, and are often terminated in a very strong hook; the labial palpi have the terminal joint very small; the spiral tongue, or maxillae, is very long; and the discoidal cell of the hind wing is not closed.” They constitute a primary division among the butterflies, which Boisduval has termed *Involuti*, from the circumstance of the caterpillars enclosing themselves in a curled-up leaf; thus, as in many other important particulars, approaching the moths. The chrysalides are mostly smooth or very slightly angular, attached by the tail, as well as girt round the middle, and enclosed in a thin silken cocoon.



FIG. 599. — Hesperian larva.

The United States are rich in species, our catalogues containing not less than

one hundred and fifty, of which over fifty belong to the genus *Pamphila*. The colors of the perfect insects, except in very rare instances, are not bright or striking, brown, black, or purplish, with series of pellucid spots, being the prevailing tints. Many of the genera have long tails to the hind wings. The body is short, very robust, the nerves of the wing unusually strong, and the flight so rapid and peculiar, that they have obtained the name of "skippers," from their short, jerking motion when on the wing. They frequently settle on flowers, leaves, or branches, as well as on the ground, with which their dull colors well asso-



FIG. 600. — *Pyrrhopyge*.

ciate. In one genus, *Pyrrhopyge*, the wings are marked with red and orange spots.

The genus *Euschemon* has but one species, *E. rafflesii*, a most remarkable insect from northeastern Australia. Though known for over fifty years in collections, it is still extremely rare, and little, if anything, has been placed on record with reference to its habits. Its antennæ are furnished with a very long and distinct hook, while the abdomen is transversely banded, as is the case in many species of moths, especially in the Australian genus *Agarista*, which, in many superficial respects, *E. rafflesii* resembles. The wings are jet black, with canary-yellow blotches, the tip of the abdomen being bright orange. It is about two and a quarter inches in expanse, and may be regarded as a beautiful and remarkable insect. *Helias* is composed of rather large insects somewhat moth-like in appearance, as the names *H. phadenoides* and *H. noctua* would indicate. They are all South American. One of the most remarkable genera of the family is *Pegathymus*, of which the larvæ are internal feeders, and from this and other peculiarities the insects were placed by Walker and others among the Castniadæ. The larva of the best-known species, *M. yucca*, feeds within the stems of the various species of *Yucca*.

Hesperia (= *Pyrgus*) is composed of small species, mottled equally with black and white, of which *H. tessellata* is common in the Atlantic States. In *Nisoniades* (= *Thanaos*) the species are dull colored, either black or brownish, with white spots, and the fringes of the wings occasionally white also. Such are *N. tristis* from California, and *N. funeralis* from Texas. *N. brizo* is a very common eastern species.



FIG. 601. — *Nisoniades brizo*.

Pamphila, as now accepted, is the largest genus, containing over two hundred and sixty species. It is very widely distributed, certain forms being found in every quarter of the globe, the American continent, however, surpassing all others in point of numbers. Our best known and commonest forms are *P. ahaton*, *P. peckius*, and *P. cernes*. These are found everywhere in the eastern states during the summer, while *P. agricola*, *P. nemorum*, and *P. sabuleti* take their places on the Pacific side of the continent. *P. massasoit*, a very pretty and local species, is found wherever the black alder (*Prinos verticillatus*) grows, the caterpillars probably feeding on that plant. The largest of the genus



FIG. 602. — *Pamphila ahaton*.

is *P. ethlius*, which is common in the gulf states, occasionally reaching as far north as Pennsylvania. It is fully two inches in expanse. The European forms of this genus

are very well-known insects, *P. comma* being a very familiar example. *Pyrrhopyge* (before alluded to) ranges from Mexico to Brazil, and is numerous in species, nearly all of them being of a blackish or greenish brown, with spots and blotches of red, white, and yellow. In this regard they depart very widely from the usual coloring of the hesperians, the fore wings of one species, *P. versicolor*, being very remarkable in their ornamentation. One species, *P. araxes*, is found in Arizona.

Ismene appears to be confined to Africa and the Indian region. About fifty species are described, in many of which the wings are deeply notched, a character not usual in the family. *Telegonus* contains some rather large insects of bright purple-blue color, variously marked with white, and often with large portions of the wings transparent. They are nearly all South American, *T. mercatus* being a familiar example. *Thymele* is one of the genera in which the hind wings are tailed, the lower surface being beautifully ornamented with mottlings of white and greenish, and, in a few species, adorned with silver spots. *T. protens*, *T. lycidas*, and *T. simplicius*, are all found within our borders, while *T. tityrus*, with its bright silvery patch on the underside of the secondaries, is one of the most abundant of all North American Diurnæ. Its larva is yellowish green, the segments much corrugated, that next to the head (as is the case in all of the family) greatly constricted, the head itself brown, with two orange blotches, giving the appearance of eyes. It feeds on the locust tree, *Robinia pseudacacia*, the leaves of which it rolls up as a shelter. Another of our very common species is *Eudamius bathylus*, which is a dull brown color, with small semi-pellucid spots. It extends nearly over the whole of this continent north of the Mexican boundary.



FIG. 604. — *Eudamius bathylus*.



FIG. 605. — *Thymele protens*.

The great family of the LYCENIDÆ next engages our attention. It comprises a numerous assemblage of small and weak but beautiful creatures, "distinguished by the minute size of the tarsal claws, the fore legs being fit for walking, the hind tibia with only one pair of spurs; the antennæ not distinctly hooked at the tip, and the last joint of the palpi small and naked. The anal edge of the hind wings slightly embraces the abdomen, and the discoidal cell is apparently closed by a slender vein. The caterpillars bear a very strong resemblance to wood-lice, the head being retractile, and the feet very minute. The body is oval and depressed; the chrysalis short, obtuse at each end, and girt round the middle as well as attached by the tail." There are about forty genera and probably thirteen hundred species. Many of them are of extraordinary beauty, shining like burnished gold, while others bear the most perfect tints of metallic blue, purple, and green. The genera are mostly separated upon the venation of the wings, the presence or absence of tails to the hind pair, the length and form of the palpi, and the structure of the legs. They are found over the entire globe, though the development of certain genera is far greater in the temperate than in the tropical zones. Few are large, none, perhaps, extending two and a half inches in expanse. They appear to fall naturally into three groups, familiarly known as the 'coppers,' represented by the great genus *Chrysophanus*, the 'blues,' of which *Cupido* or

Lycæna may be cited as the type, and by the 'hair-streaks,' of which *Thecla* may be the example. The first of these has the wings, at least of the male, of various shades of copper or golden brown, marked with black spots and dashes, the genus being mostly confined to the temperate regions of the globe. In this country we have several beautiful species, the rarest of which is, perhaps, *C. capreus*, which is found only on the rim of the Yosemite Valley, and as yet is extremely rare in collections. It is of a very fiery golden copper, with the black spots usually large. *C. rubidus* is confined to the valleys, and an allied species, *C. sirius*, is met with only in the Rocky Mountains. *C. americana* (very nearly resembling *C. phleas* of Europe, and by many persons thought to be identical with it) is abundant through the middle and eastern states; and perhaps there is no butterfly so common about the middle of the summer and even far into the fall, as this lively and attractive little species. Its caterpillar is well known to entomologists, and feeds upon the common sorrel, *Rumex acetosella*. "It is of a dull rosy-red color, with a diffused yellowish shade on the sides, most distinct on the middle segments, and a line along the middle of the back of a deeper shade of red. The body is downy with minute yellowish hairs." Some of the larvæ, as is usual with all the species of the genus, are of a greenish color. The chrysalis is fastened by the end of the abdomen, and is closely girt by the band around the middle to the object to which it is attached. The species has a great tendency to run into curious varieties, at times the black spots being almost obsolete, having only one or two on the fore wing, thus presenting a remarkable golden surface, and from this form through every modification until the wings become almost black with only a trace of copper. These aberrations, one of which has been called *C. fasciatus*, are by no means common; and it is worthy of remark that they are chiefly found in the neighborhood of Boston, Mass. The writer one year examined over two hundred examples taken around New York city, and found only one that at all wandered from the type, and that had the copper color so faded out as to have become nearly white, thus in no respect resembling the varieties from around Boston. *C. epixanthe* and *C. doreus* are allied species that appear to frequent swamps, the former being common in Maine, and the latter found only in British America and across the continent to Alaska, in which territory it appears to be one of the few *Lycanids* known. Many species of this section are found in Europe and Asia, two or three only wandering as far as the northern Himalayas. *C. virgaureæ* and *C. thersamon* are very bright in their color, and are found generally distributed over Europe, while the 'large copper' as it was commonly called, *C. dispar*, formerly taken in the Cambridgeshire fens, England, is now thought to be extinct, as since the drainage of the fens it seems to have disappeared.

The beautiful genus *Thestor* contains but three species, all natives of eastern Europe. They have the wings of a different shape, and the lower side is curiously marked with white, while the copper of the upper surface is less brilliant than in *Chrysophanus*.

The 'blues,' belonging to Fabricius' genus *Lycæna*, are much more numerous in species, there being not less than three hundred and thirty already described. They spread over the whole world, and are generally numerous in individuals, some of them loving the tops of mountains, while others are confined to the valleys and plains. The United States are very rich in species, Edwards's catalogue giving over fifty as inhabitants of this country. None of them are particularly handsome insects, but they are peculiarly interesting to the entomologist. One species, however, is of great beauty. It has the upper surface of a bright silvery blue, with a rich orange patch on the disc

of the wings, most apparent in the female. It is found only on the Pacific coast, and is there apparently confined to few localities, being one of the few butterflies inhabiting the inhospitable promontory of Lower California. The name of this little beauty is *L. sonoriensis* (= *L. repta*). Mr. W. G. Wright says: "During the whole trip this delicate butterfly was seen only at one place, a dry mesa, or beach, close by the shore, and shut in by some circling cliff-like hills. There, in a little basin, and almost in the midst of the thundering surf, there were hundreds of them. As one was caught, one or more others were sure to be seen. The ground was in good part covered with impenetrable clumps of cactus, and between and among these grew the plant of these little butterflies, *Erodium cicutarium*, upon which the females were depositing their eggs. I thought it rather singular that this most tender of all butterflies should be breeding at this season (January, 1883), and directly in the breath of the ocean." California and Oregon produce many species of the genus; on the slopes of the Sierra Nevada and other mountains they are sometimes seen almost in clouds, *L. phœx*, *L. anticius*, and *L. aemon* taking the lead in point of numbers. *L. xerxes*, formerly found near San Francisco, in which the pupillate spots of the lower side are almost obsolete, appears to be now extinct, as the spot on which it was formerly taken has of late years submitted to drainage and other "modern improvements."

The eastern and middle states produce but few species, *L. pseudargiolus* being the most frequent. This runs into other forms, such as *L. neglecta*, *L. pius*, and *L. lucia*, the specific value of which has been treated by Mr. W. H. Edwards, and their relations to each other clearly shown. Three or four are found in Florida, passing over into the West Indies, and thence becoming scarcer as we get nearer to the equator. The genus is plentiful in Europe, some of the species, such as *L. acis*, *L. adonis*, and *L. arion* being of much beauty. These are exquisitely blue insects, with silver and orange spots arranged around the margins. Some European forms are brown, with orange markings, one of the most curious of these being *L. artaxerxes*, exclusively an inhabitant of Scotland, and at one time supposed to be only found near Arthur's Seat, Edinburgh. It is said by many to be no more than a local variety of *L. agestis*; but Westwood remarks that, "although *agestis* is very abundant on the Continent, the continental entomologists have never met with a single specimen of *artaxerxes*, their cabinets being entirely furnished with Scotch specimens." A large number of species, mostly Asiatic, have the hind wings provided with tails, thereby approaching in this one particular the genus *Thecla*. It is, however, doubtful if this character be of any value, and an eminent writer on the group we are discussing says: "The presence or absence of a tail appears immaterial. Witness *L. illissus*, tailed; *L. faggetus*, tailless. The foregoing observations seem to me to prove that the characters in question, although still relied upon by some entomologists as of generic value, can in no way be depended upon, and that if the genus *Lycæna* is to be divided we must find some better character on which to found our new genera." To this tailed group belong our very common *L. comytus*, the European *L. horta*, and the East Indian *L. plato* and *L. elpis*.



FIG. 665. — *Lycæna pseudargiolus*.

Thecla, as at present constituted, contains more species than any other known genus of lepidopterous insects, nearly five hundred being included in our catalogues, natives of all parts of the globe, and, contrary to the rule with *Lycæna*, abounding in

the tropics. Though shades of orange, brown, and even black are found amongst them, the colors which preponderate are brilliant blue and green, of every shade, and of the brightest metallic lustre, the under side being usually ornamented with one or two delicate lines of pale color on a dark ground; whence the name of "hair-streaks" has been given by collectors to these butterflies. There is generally a blotch of some bright color near the anal angle, which attains a more pronounced development on the lower side of the wing. The insects are for the most part only moderate in size, the largest scarcely exceeding two inches in expanse. Among the grandest of the group are *T. coronata*, *T. imperialis*, and *T. regalis*, which are Brazilian species, and, as their names imply, are the regnant beauties of the Theclan court. They are brilliant blue, with dusky borders, the under side magnificently ornamented with red, orange, gold, and lilac. At present they are rather scarce in collections.

T. halesus is a fine species found in the southern states, extending also as far west as California. It is of a deep metallic blue, with black shadings, and is marked beneath with spots of green and gold. Other species allied to it, and probably undescribed, are found in Mexico, one of which may prove to be *T. juanita*. *T. chrysalus* is another beautiful form from southern Utah and Colorado, which had, until about seven years since, eluded the vigilance of collectors. The color in this species is bright violet purple, with orange patches. It is one of the most striking insects of our fauna, appearing only to frequent mountainous districts. *T. M-album*, of the gulf states, is bright mazarine blue, with black border, and a white dash beneath in the form of the letter M, whence its name. The remainder of our species are dull-colored insects, mostly brown, with orange and blue markings. *T. spinctorum* is of these most conspicuous for its rarity and beauty. The under side is streaked with lines of orange, edged with white, on a purplish-brown ground. It has only been taken on about six occasions in the mountains of California, chiefly in the neighborhood of Shasta, its favorite plant being *Arceuthobium campylopodium*, a



FIG. 606. — *Thecla niphon*.

species of mistletoe growing upon pine trees. A few *Theclas*, such as *T. rubi*, of Europe, *T. affinis*, of the Rocky Mountains, and *T. dimetorum*, of California, are bright grass-green on the lower side, so that when the insect is at rest, and its wings vertically folded, it cannot be distinguished from the herbage to which it clings. Others, again, like *T. niphon* and *T. eri-*

niphon, both of our own fauna, have the lower side brownish,

mottled with darker shades, like a decaying leaf.

Europe possesses several fine species, the brightest colored being *T. quercus*, in which the wings are shaded with bright violet-purple. It is a common insect, being found flying in oak woods, sometimes in great abundance. It is, however, difficult to capture, as it rarely descends to the ground. Indeed, this peculiarity may be remarked of nearly the whole of the species. *T. W-album*, *T. betulae*, and *T. pruni* are also well known European forms. *T. marsyas* has the fore-wings very acute at the apex, of a brilliant silvery blue, almost dazzling in the sunlight, while beneath the color is a sober quaker-drab, with very slight ornamentation. This beautiful species is very common, in one or other of its forms, from Mexico southward to Brazil. It flies mostly in sandy places; and in some districts it is frequent on the dunes of the sea-shore, alighting on the low herbage which scantily covers them. As it then folds its wings, hiding the blue surface, it is impossible to distinguish it, as the dull coloration of the under side harmonizes exactly with its sandy resting-place. Africa produces but few

species, the bulk of them (as has been stated) belonging to tropical America and Asia. There are no true *Thelctas* in Australia, their place there being occupied by allied genera, as *Hypochrysops* and *Jalmensis*. *J. caryotas* is a common species in some parts of the island, the larvæ feeding in large companies on the young leaves of the wattle, *Acacia decurrens*.

Ogyris is a singular genus, in which the male and female are very unlike, both in form and coloring, some of the latter having orange or yellow spots, while the males are the brightest purple. They are natives of Australia, and delight to fly about the tops of the tall eucalyptus trees. Nothing is known of their earlier stages. A very aberrant genus *Eumaus*, with four or five species, occurs in Florida, Central America, and the West Indies. The species are very beautiful, bronze-black, with bright green or blue maculate borders and a golden sheen over all.

We pass by *Eumaus* to the next family, generally known as the ERYCINIDÆ; but, according to Mr. Kirby, this name is pre-occupied, and he proposes in its stead that of LEMONIIDÆ. The family is sub-divided into the following sub-families: Lemoniinae, Euselasiinae, Nemeobinae, and Libythæinae. They are generally characterized by the male having but four perfect feet, while the female has six, the sub-families being distinguished by minor details of habit and structure.

The Lemoniinae are, for the most part, very beautiful insects, adorned with bright colors, such as red, yellow, orange, and green spots on a black ground. There are also many very peculiarly formed species in this group, in which the secondaries are furnished with fine tails, such as the exquisite genus *Helicopsis*, of which *H. cupido* and *H. acis* are well-known species from Brazil. In these the wings are yellowish white, with the base orange, the borders blackish, and the under side beautifully spotted with shining silver. But few species of Erycinidæ inhabit the United States, the most singular forms being *Apodemia*, of which three species, *A. mormo*, *A. virgulti*, and *A. palmeri*, are pretty brown insects, with white chequered spots, the first being found in Nevada, the second in southern California, and the last in Arizona. Allied to these, though probably of a different genus, is *Lenonias nais*, first described as a *Chrysophanus*. It is from southern Utah and Colorado. Two species of *Charis* are also found in our limits. They are orange-brown in color, with the lower side of a more vivid shade, with a number of black and silver dots arranged in the form of bands. They are among the smallest of our butterflies.

The Euselasiinae, or Eurygoninae, are curious forms, in which the wings are often very abruptly truncate at the apex, with deep sinuses along the margins. There are over seventy species of this sub-family.

Of the Nemeobinae the typical genus *Nemeobius* is represented in Europe by the single species *N. lucina*, a small orange-brown insect, with black dots and marks, at first sight like one of the "coppers" of the family Lycaenidæ. It also bears a superficial resemblance to some species of *Melitæa*. It is rather common in France and Germany, and has also been taken in some abundance in various parts of England. The caterpillar has been described by Hübner as feeding on primrose and cowslip, *Primula veris* and *P. clatior*. "Its color is pale olive-orange, with black dots, with bristly warts and long feathery hairs. It moves very slowly, rolls itself up when disturbed, and remains a long time in that state. Its appearance at different ages varies considerably."

The Libythæinae has but one genus, *Libythæa*, in which the palpi are prolonged into the form of a beak and the wings are robust and angular. There are but eight species

known, of which the half are natives of the New World. The larvæ are described as being without spines, slightly pubescent, and finely shagreened. The chrysalis is short and slightly angular. One of the species, *L. cellis*, is common in Europe, reaching also into Asia Minor. All of them appear to be subject to great variation, and it is possible that many now accepted as a species may ultimately prove to be mere local forms. They are brown insects, marked with yellow and white.

It has been said that the NYMPHALIDÆ are, in point of numbers, whether of individuals or of species, the most abundant of all diurnal Lepidoptera, containing some of the most familiar forms, and including many which have no *special* home, but are scattered over the whole surface of the globe. The following are briefly the characters of the group: Larva cylindrical, with fleshy processes or spines; Chrysalis stout, smooth, and rounded, or angular in outline, always suspended by the tail; Imago, with the body stout, a large groove on secondaries for the reception of the abdomen, discoidal cellule mostly open, fore legs aborted, hooks of the tarsi generally bifid. About three thousand species are known.

The sub-family Nymphalineæ is the largest of the whole group of diurnal Lepidoptera, and in its one hundred and thirteen genera comprises some of the most interesting and beautiful of all butterflies. Their chief characters have been defined as follows: "Larva cylindric, spinose the whole length, or only on the head; Chrysalis variable, but usually spinose; Imago, with the palpi close, elevated, very scaly, the anterior face of their first two articles nearly as wide or wider than the sides, abdominal edge of the secondaries forming a deep groove to receive the abdomen; Antennæ with a distinct knob or club, discoidal cellule nearly always open, hooks of the tarsi bifid." They are very rapid flyers, and are among the most active of all lepidopterous insects. They are confined to no particular region of the globe, several species having wandered over the whole of the earth's surface, apparently not affected by climatic conditions, but faring as well among the snows of the Arctic as in the hot blasts of the African deserts, *Vanessa antiopa*, for example, being recorded from Alaska to Brazil on this continent, and from Lapland to North Africa on the old.

Anax (far better known as *Paphia*) is composed of species in which the fore wings are distinctly hollowed out on the external margin, leaving the apex an extremely sharp angle, and also very frequently with the same excavation along the inner margin, the hind wings of most species being furnished with a narrow, pointed tail. There are nearly sixty species known, all from Central and South America, two of them, however, *P. andria*, long regarded as identical with *P. glycerium*, and *P. morisonii*, crossing our borders into Florida and Arizona. Mexico is rich in species of this group, one of them, *P. callidryas*, looking at first sight very much like the paler forms of *Callidryas* and *Gonepteryx*. *Siderone* bears a great resemblance to the last-named genus, but the body is stouter, the antennæ longer, and the wings not so deeply excavated. One species, *S. ide*, has a black ground, with large blotches of the deepest crimson.

Hyppia has spatulate tails, the wings deeply indented on the margins, and the lower side ornamented with spots of silver. Mr. A. G. Butler has published a monograph of the genus, in which he enumerates seven species. These, however, are said by Kirby to be referable to one species, the original type of the genus being *H. clytemnestra*. The species are South American. *Mypes* is represented by only three species, of which *M. guerini*, from Queensland, has the upper side greenish white,

with black borders; the lower marked with black, red, and yellow. It has very much the aspect of certain Pieride of the genus *Delias*.

Nymphalis, or *Charaxes*, is a genus of about sixty species, in which the wings are triangular in outline, very much produced at the apex of the primaries, with the hind pair each usually provided with two, three, or at times four tails. The nervures, especially of the anterior pair, are very much thickened, as in *Proponot* and other genera. The thorax is very thick and stony, the abdomen rather small, received into a groove



FIG. 607. — European butterflies: *a*, *Limnitis populi*; *b*, *c*, *Chrysophanus virgata*; *d*, *C. phlaeas*; *e*, *Lycæna adonis*; *f*, *Hesperia comma*; *g*, *Nemobius lucina*.

on the margin of the hind wings. The larvæ have usually four vertical horns on the head, of which the two intermediate are the longest. The species are all natives of the Old World, and are usually more gaily colored on the lower than on the upper side. *N. jason* is a fine European species, and perhaps one of the handsomest butterflies included in the European fauna. It is about four inches in expanse, the surface of a rich, silky brown, changing with the light, a band of fulvous around the margin of the wings, with some blue spots near the anal angle of the secondaries. Beneath, the wings are rust-red, with bands and spots of brown, white, and gray. It is found chiefly along the shores of the Mediterranean, and extends to Asia Minor. The larva

is green, with a row of yellow spots, and the chrysalis green, smooth, thick, and coriaceous in texture. It produces two broods during the year. "In many parts of France the butterfly is named 'the Pacha with two tails.'" It is probable that most of the species have the same life history as *N. jason*, the earlier stages of which have been carefully studied by M. Lefebure of Toulon. Those inhabiting the west coast of Africa are very fine and remarkable insects, and *N. brutus*, *N. etheocles*, and *N. etesipe* and others are among the wonders displayed in the cabinet of the enthusiast. Australia produces a beautiful form in *N. sempronius*, which is abundant in gardens near Sydney, delighting to settle on the flowers of *Bursaria spinosa*, and is perhaps one of the larger butterflies most frequently seen in that delightful country. Another grand species was captured by Mr. Wallace in Java, viz., *N. kadenii*, which is "remarkable for having on each hind wing two curved tails like a pair of callipers." Many others are also taken in India, of which the best known, and perhaps the most common, is *N. athamas*, which is black, with very broad median band of yellowish green. The most variable species is *N. polygona*, of which not less than seventeen forms are recorded under different names. It extends from India proper through the islands of the Borneo group, southward to Ceylon, presenting considerable change of feature in its different locations.

Prepona consists of large and powerful insects, in which the upper side of the wings is variously marked with purple-blue shades, while the lower is stone-drab or fawn color. These insects rest very much upon the trunks of trees, and when the wings are folded and erect, it is almost impossible to distinguish them from the bark upon which they are placed. This must serve as a great protection, as the shiny blue wings would render them an attractive object to birds and other enemies.

Apatura is a most beautiful genus, in which the very long antennae are surmounted by a cylindrical club, the thorax long and robust, the abdomen small, the wings slightly dentate, always with one ocellus, if not more, on the lower side, the outer edge of primaries and the anal angle of the secondaries slightly concave. They are very robust and powerful insects, and are noted for their long and vigorous flight. Many of the species have the most glorious lilac, purple, or blue reflection, and may be regarded as very handsome insects. *A. iris* is a European species of great beauty, so much so as to have obtained the familiar name of the "Purple Emperor." It has the wings of the richest purple, with a few white spots at the apex, and a rather narrow band of white common to both wings. Near the anal angle is an orange ocellus, with a black pupil, while the under side is profusely ornamented with brown, orange, and white. Like many of its tribe, *A. iris* is a very high flier, and, as Westwood says, "delights to fix his throne on the summit of a lofty oak, from the utmost sprigs of which, on sunny days, he performs his aerial excursions, defending his territory against a rival emperor with the greatest energy. The females are much rarer, and do not take such lofty flights as the males."

Limenitis is distinguished by having the head narrower than the thorax, the antennae almost as long as the body, and the wings wide, slightly dentate, and destitute of ocelli. We have seven or eight species in the United States, one of which, *L. lorquini*, is only found on the Pacific slope. It is in coloration allied to *Adelpha*, and, from the structure of its caterpillar, should probably form the type of a distinct genus between it and *Limenitis*. *L. weidemeyrii* is a very fine species from the Rocky Mountains; while *L. astyanax* (or *L. ursula*) and *L. artemis* are by no means uncommon in the middle and eastern states. *L. proserpina* is now

believed to be a dimorphic form of the latter species. *L. missippus* resembles greatly in color the common milk-weed butterfly (*Danaus archippus*), but it is of course very different in structure both in the larval and imago stages. It is one of our most abundant species.

L. camilla and *L. sibylla* are European. They are brownish black, with white markings, and are remarkable for their graceful flight. It is related by Mr. Haworth that "there was an old aurelian of London so highly delighted at the inimitable flight of *camilla* that, long after he was unable to pursue her, he used to go to the woods and sit down on a stile, for the sole purpose of feasting his eyes with her fascinating evolutions."

Adelpha, or *Heterochroa*, is a large genus containing nearly seventy species of brownish butterflies, with white bands, and some spots of orange and black, the under side being white with streaks and bands of orange of various shades. They are nearly all Central and South American, and are by no means rare. One very fine species, and perhaps the largest of the group, *A. californica*, is abundant in all parts of California, where its larva feeds on oak. The butterfly is fond of alighting on drainage or putrescent matter, and, when so settled, it may be easily captured; but, otherwise, it is a strong and wild insect, and darts away at the slightest cause for alarm.

Victorina has five species, all of which are large and showy insects, *V. superba*, from Mexico and Central America, being particularly so. *Hypolimnion* holds a large number of fine butterflies, in which the prevailing color is brilliant purple or blue, with large whitish ocelli, or other marks. The best-known species is *H. bolina*, which is remarkably variable, no less than fourteen separate forms having been described. It is somewhat singular that this species, whose home appears to be India, should have found its way to the West Indies and even to Florida.

Batesia is a genus of large insects, over four inches in expanse, the upper side of the wings being brilliant steel-blue, with blackish markings; the under side of the lower pair, in one species, *B. prola*, being wholly bright brick-red. A lovely genus of more subdued colors is *Ageronia*, these butterflies being mostly of grayish tints, mottled with black or brown in streaks or squares. They are common in the tropics of America, are strong fliers, and are remarkable for their habit of sitting with the head directed downward, and the wings outspread upon the trunks of trees, as well as for a singular noise which they make when upon the wing. Mr. Darwin thus alludes



FIG. 608. — *Batesia*.

to one of the species: "I was much struck with the habits of *Papilio* (*Ageronia*) *feronia*. This butterfly is not uncommon, and generally frequents the orange groves. Although a high flier, it very frequently alights on the trunks of trees. On these occasions its head is invariably placed downwards, and its wings are ex-

panded in a horizontal plane, instead of being folded vertically, as is commonly the case. This is the only butterfly which I have ever seen that uses its legs for running. Not being aware of this fact, the insect, more than once, as I cautiously approached with my forceps, shuffled on one side as the instrument was on the point of closing, and thus escaped. But a far more singular fact is the power which this species possesses of making a noise. Several times when a pair, probably male and female, were chasing each other in an irregular course, they passed within a few yards of me, and I distinctly heard a clicking noise, similar to that produced by a toothed wheel passing under a spring catch. The noise was continued at short intervals, and could be distinguished at about twenty yards distance. I am certain there is no error in the observation." Mr. Edward Doubleday described before the Entomological Society on March 3, 1845, the peculiar structure of the wings of this butterfly. He says: "It is remarkable for having a sort of drum at the base of the fore-wings, between the costal nervure and the sub-costal. These two nervures, moreover, have a peculiar screw-like diaphragm or vessel in the interior." A similar structure obtains in some species of moths; and in the zygenid genus *Heatesia*, of Australia, the "whiz, whiz," of the male insect, which is like the noise produced by a humming-top, may be heard at a great distance. *A. feronia*, though it travels as far north as Mexico, appears to be most abundant in Brazil.

Still handsomer, if possible, are the species of *Callithea*, confined to the Amazonian region, where all the species known, with the exception of two, were captured by Messrs. Bates and Wallace. *C. sapphira* (male) is the most intense cobalt-blue that can be conceived, so bright as to be all but dazzling to the eye. *C. markii* is purple and orange. *C. whitleyi* and *C. buckleyi* are equally striking in their colors, and from their extreme rarity are especially valued in collections. Mr. Wallace says: "The two beautiful butterflies, *C. sapphira* and *C. lepicurii*, which were originally found, the former in Brazil and the latter in Guiana, have been taken by myself on the opposite banks of the Amazon, within a few miles of each other, but neither of them on both sides of that river. Mr. Bates has since discovered another species, named after himself, on the south side of the Amazon; and a fourth, distinct from either of them, was found by me high up in one of the northwestern tributaries of the Rio Negro, so that it seems probable that distinct species of this genus inhabit the opposite shores of the Amazon."

Precis has the wings more or less falcate at the apex, and some of the species have the hind pair somewhat produced into a tail. They are all natives of Africa and the East Indies. *Salamis* is also an African genus, the best-known species of which, *S. anacardi*, is of a beautiful opalescent green tint, the ocelli being surrounded by black rings. In *Kallima* the upper side of the wings has broad bands of purple and orange, but the under side is brown, and, when folded, has all the appearance of a dead leaf. Mr. Wallace gives a most charming account of this very interesting insect. He says: "This species (*K. paralekta*) was not uncommon in dry woods and thickets, and I often endeavored to capture it without success; for, after flying for a short distance, it would enter a bush among dry or dead leaves, and however carefully I crept up to the spot I could never discover it till it would suddenly start out again, and then disappear in a similar place. At length I was fortunate enough to see the exact spot where the butterfly settled; and, though I lost sight of it for some time, I at length discovered that it was right before my eyes, but that in its position of repose it so closely resembled a dead leaf attached to a twig as almost certainly to deceive the eye even

when gazing full upon it." The end of the upper wings terminates in a fine point, as the leaves of many tropical shrubs and trees are pointed, while the lower wings are more obtuse, and are lengthened out into a short thin tail. Between these two points there runs a dark curved line representing the midrib of a leaf, and the outline of the wings when pressed close together is that of a moderately sized leaf slightly curved or shrivelled. The habits of the insect are such as to utilize all these peculiarities, and render them available in such a manner as to remove all doubt as to the purpose of this singular case of mimicry, which is undoubtedly a protection to the insect.

Closely allied to *Kallima*, and like it, very leaf-like on the lower side, is *Dolichschallia*, of which the most common species is *D. bisaltide*. This is found in various varietal forms throughout the East Indian region, as well as in the northern portions of Australia. *Anartia* has one species, *A. jatropha*, in our fauna, which is by no means rare in Florida. It is brownish white, with a row of small ocelli around the margins.

The genus *Colanis* has one exquisite species, *C. dido*, in which the wings are brownish, with pale sea-green markings. It is very aberrant in these respects from its congeners, which are light brown marked with black. The caterpillar of the species alluded to has been figured by Madame Meriam. It is of a green color, having a red and white ray along each side of the body. It bears several rows of short spines, rising in a radiated manner from a tubercle, and two very long caudal appendages. *Dione* or *Agraulis* is represented in this country by a species very common in the southern states, and extending across the continent to southern California, viz., *D. vanilla*. Its bright orange-brown wings, marked with black spots, with the lower side adorned with large patches of silver, render it a very conspicuous and striking insect among the passion-flower plants on which the larva feeds. *D. moneta* is a form found from Mexico to Brazil, smaller in size than *D. vanilla*, but with the silver blotches of the under side even more strongly marked.

The two species of *Euptoicta*, *E. claudia* and *E. hegesia* are North American insects, the former extending from New York State to southern Mexico, and the latter from the southern portion of California, through Mexico, to Panama, and probably still further south. They are nearly related to the next genus, *Argynnis*, which is abundantly represented on this continent, out of the seventy-five species catalogued by Kirby, not less than twenty-eight being natives of the United States. The grandest of them all, *A. diana*, is peculiar to Virginia, where it flies in the middle of the day, darting into the depths of the forest on the approach of an intruder. The male is about four and a half inches in expanse, the wings rich chocolate-brown, with very broad bright orange margin, while the female is a little larger than her mate, and has the border bluish



FIG. 609. — *Argynnis obtusa*.

steel color, the lower side of both sexes being marked with silver spots. This is unquestionably one of the handsomest insects found in the United States, and is justly regarded as a great prize by the collector. The caterpillar feeds, as indeed

do all of the genus, upon violets or allied plants, but hitherto it has been impossible to raise the species in captivity. *A. cybele* and *A. aphrodite* are among our most common species, the former being taken in great numbers in June about the flowers of thistles and other composite plants. *A. atlantis* is abundant in the White Mountains, N. H., and a small species, *A. montinus*, is met with only in the same range, but is of considerable rarity, Mr. Seudder remarking that "probably no collector has seen more than eight or ten of these butterflies in a day's scramble among the mountains. They fly close to the ground, among the scanty foliage growing in the rocky crevices of the steep mountain slopes." California, and indeed the whole of the Pacific States, produce some fine species of *Argynnis*, *A. leto*, and *A. ukomis* being remarkable for having the female almost black. The former of these is somewhat common in the Yo-

semite valley and about the base of Mount Shasta; the latter is only met with in Utah and Arizona.

Europe and Asia also furnish handsome species of the genus. By some authors the genus has been subdivided, and the smaller species, in which the under side is without silver spots, and the wings narrower



FIG. 610. — *Argynnis bellona*.

and more produced, have been assigned to the genus *Brenthis*. Of this section, to which *A. montinus* (alluded to above) belongs, our most common species is *A. bellona*, which is abundant throughout the summer in swampy meadows.

Melitæa contains nearly fifty species, nearly all of which are natives of Europe and North America, a few only being found in Amoorland and Kamshatka. They are prettily marked with brown, yellow, and white chequered spots, without silver on the under side, which is variously adorned with bands of white and yellow. Two of the most conspicuous species of this country are *M. phæton* and *M. chalcon*. The former of these, though somewhat local, is occasionally found in great numbers in its haunts, and is apt to run into very peculiar aberrations, the wings becoming suffused, and losing nearly all trace of the original markings. The food plant is the *Chelone glabra*. *M. chalcon* is abundant in spring in California, and may be found in company with *M. palla*, flying on warm days in almost every flowery meadow. Its chrysalis is clear white, with black and yellow spots, and is a very pretty object. The larva feeds upon species of *Scrophulariaceæ*, but its favorite plants are *Diplacus glutinosus* and *Castilleja parviflora*. It is black, with yellow tubercles, and is furnished with long black spines. The larvæ in their young stages are gregarious, and hibernate in a curiously formed web, as also do those of *M. phæton*.

Phyciodes and *Eresia* are large genera, containing together (having been united by recent authors) over one hundred species. They are mostly brownish, with yellow or white spots and blotches, small in size, and not particularly attractive, save to the scientific observer. *P. tharos* is one of the commonest of North American butterflies, being abundant everywhere from May to September.

Grapta includes a number of European and American species, in which the wings are very angular, deeply excised in the border, the underside of secondaries bearing a



FIG. 611. — *Phyciodes tharos*.



AMERICAN BUTTERFLIES.

1. *Pyranis cardui*.
2. *P. huntera*.
3. *Vanessa milberti*.
4. *Grypha interrogationis*.
5. *Vanessa anthopa*.

mark like the letters L or C, in gold or silver. The North American forms are numerous and very beautiful, *C. interrogationis* being the largest and most striking. This is a common species in the southern States, and is met with, though in less abundance, as far north as Maine, and occasionally in Canada. The larva feeds on hop and elm chiefly. *G. foveatus*, *G. progne*, and *G. comma* are, at times, also common species, the last named being thought by some entomologists to be the same as *G. Calbum* of Europe. *G. gracilis* is a fine species peculiar to the White Mountains, and has the under side prettily shaded with white and green. The caterpillars of the *Grapta* are mostly whitish, with orange and brown shades, and are profusely covered with small, tubercular spines. They cannot be said to be destructive in their habits, as the only cultivated plant they are found upon is the hop, and to this they do but little damage. The chrysalides are very angular and spiny, and are generally ornamented with bright golden spots.

Of the true genus *Vanessa*, which, as now limited by entomologists, differs from *Grapta* in having smaller and shorter palpi, in the much smaller excisions of the wings, and in the larva being without spines on the head, the most widely spread species is *V. antiopa*, which, as has been previously said, is almost world-wide in its range. This well-known insect, as common on the continent of Europe as it is with us, has the upper side of the wings of a rich purplish brown, with a rather broad cream-colored margin, in which are several bright blue spots, while the lower side is charcoal black, flecked with yellowish scales. It is very strong on the wing, and may be often seen flying about roadsides in summer, chasing its brethren, and engaged with them in severe encounters, often passing far up out of sight, and continuing the warfare into "the blue." A very singular variety, in which the cream border is remarkably wide, and the blue spots are absent, has been named, by the late Dr. Asa Fitch, *V. lintneri*, and Mr. S. L. Elliot of New York has raised some still more abnormal forms, in which the brown of the wings is more completely encroached upon by the paler shade. The eggs are laid (according to Professor Fernald) "in a cluster around the twigs of willow, elm, or poplar, near the petiole of a leaf, on which the young larvæ feed." These are blackish, with small white dots, and with a row of brick-red blotches on the dorsal region.

V. io is one of the most singularly beautiful of European Lepidoptera, its deep reddish wings, with large eye-like spots in which yellow, black, lilac, rose, and white are all intermingled, rendering it an object of admiration to every beholder. The under side is deep black. It is a very common species in Europe, being found during the summer in almost every garden. The caterpillars are gregarious, and feed exclusively on the



FIG. 612. — a, *Vanessa io*; b, pupa; c, larva; d, *Eponiphthe gaura*; e, larva.

common stinging-nettle, *Urtica dioica*. *U. urticae* and *U. polychloros* are also well-known European forms, the caterpillars of which are very much alike, that of the former feeding on nettle, of the latter on elm. They are represented in this country by two allied forms, *U. milberti*, recalling *urticae*, and *U. californica*, being nearly related to *polychloros*. The last-named species, in its larva stage, feeds on *Ceanothus thyrsiflora*, to which shrub it is at times extremely destructive.

Pyrameis is distinguished from *Vanessa* by having "the wings still less angular, palpi less hairy, and in somewhat different form; the club of the antennæ is rather more pointed; the larvæ have all the segments, except the head and prothorax, armed with long spines set round with whorls of stiff bristles. They differ also in habit, those of *Pyrameis* are always solitary, drawing together the sides of a leaf with silken threads, and thus forming a cylindric dwelling; the pupæ are similar in shape and markings." The most familiar species is *P. cardui*, the "painted lady" of English collectors, which is spread over the whole of Europe, through a large part of Asia, across Behring's Straits and down the Pacific Coast to Peru, appearing again on the eastern side of the continent, and becoming abundant in the middle and northern portion of the United States. It is also met with in the Sandwich and Fiji groups of islands; and a closely allied form, *P. kershawii*, evidently an offshoot from the main branch of the species, is abundant in Australia. "Painted ladies" have thus made their way over a considerable portion of the earth's surface. The larva of *P. cardui* feeds exclusively on thistles. It is blackish or greenish brown, with yellow dorsal and lateral lines.

A pretty species closely allied to this is *P. caryæ*, which extends along the west coast of America from Oregon to Chili, and is one of the most abundant butterflies of California and western Mexico. The food plants of the caterpillar are various species of *Malva* and *Lavatera*. *P. tamneamea* is one of the few butterflies found in the Sandwich Islands, and is, perhaps, the grandest of the genus. It is strongly marked with bright red blotches, and frequents the thick forests at the base of the volcanic mountains of those beautiful islands. It is at present extremely rare in collections,



FIG. 613. — *Junonia cecilia*.

and nothing has been recorded regarding its earlier stages. *P. gonerilla* is a native of New Zealand, and *P. itea* of Australia. The caterpillars of both of these species are black, not unlike those of *V. io*, and like them feed upon urticaceous plants.

Junonia is a very distinct genus from *Pyrameis*, having naked eyes, and less hairy anterior legs. The cells of both wings are nearly always open, the larvæ have the head always spinose, and the chrysalis is tuberculated, but rarely angular.

The wings are always marked with large or small ocelli. *J. delia*, *J. orithya*, and *J. æonone*, all East Indian species, are beautifully marked with purple and orange. *J. laomedea* is grayish fawn color, and the rest of the species are shades of brown with variously sized ocelli. One species, *J. cecilia*, is extremely common in Georgia and Florida, and occasionally so in the northern states.

The Heliconiæ are closely allied in appearance to the next sub-family; but they are slighter insects, have the wings more produced, with the antennæ and abdomen proportionately longer. The discoidal cellule is always closed. There are but two

genera, *Heliconius* and *Eucides*. They are all peculiar to the American continent. "The prevailing ground-color of the wings of these insects is deep black, and on this are depicted spots of crimson, white, and bright green, in different patterns according to the species. Their elegant shape, showy colors, and slow, sailing mode of flight, make them very attractive objects, and their numbers are so great that they form quite a feature in the physiognomy of the forest, compensating for the scarcity of flowers." One species, *H. clarithonia*, in which the wings are black with greenish yellow markings, is very abundant in Florida. This genus is shown in the plate opposite p. 120 of this volume.

The Acraeinae has but two genera with about eighty-five species, the typical genus *Acraea* being for the most part composed of African insects with semi-transparent wings, of reddish brown colors, marked with black spots, of an endless variety of pattern. They are nearly all rather small insects, few being above three inches in width. The caterpillars are spinose and the chrysalides also are furnished with short spiny processes, many of them being marked with golden spots. Some of the species from the west coast of Africa are very beautiful, shades of red of various degrees of intensity prevailing amongst them.

The Brassolinae are like *Morpho*, but with brown wings, *Brassolis* and *Opsiphanes* having very short bodies, with the antennae thickened at the tips, especially in the females. *Caligo* contains some very large insects, *C. eurylochus* or the "owl-butterfly," as it is sometimes called, being common throughout South America. Its expanse of wings is sometimes nine inches, and when they are folded by the insect in a state of rest, the large ocelli at base of secondaries look like a pair of eyes of some small species of owl, thus, no doubt, protecting the insect from the attacks of birds and other enemies. *C. uranus* has a brilliant bar of orange transversely across the wings. The Brassolinae are all natives of America and the West Indian Islands.

We now approach a group of Nymphalidae, which contains some of the largest and at the same time the most beautiful of Lepidopterous forms, and which, though not numerous, either in genera or species, is full of interest to the student of nature. The Morphinae have the wings large, with a groove in the secondaries for the reception of the abdomen, which is short, and, considering the size of the wings, remarkably small. The nerves at the base of the primaries are greatly developed, the wings are rounded in the outline, the discoidal cell of secondaries always open, and the antennae almost hair-like, or, at least, very slightly thickened at this extremity. The wings beneath are adorned with ocelli, generally of large size.

It is somewhat singular that the Morphinae should be found only in the East Indian Islands and the warmer portions of the American continent, the whole of Europe, Africa, and the most of the main land of Asia possessing no representative of the tribe. They thus naturally divide themselves into two sections, that of the East Indian Archipelago, for the most part, containing smaller and duller-colored insects than the group inhabiting Brazil and Central America.

The true *Morphos* are, as has been said, found mainly in Brazil, only two or three species reaching as far north as Mexico. Notable among these is a large white one, with rather small brown ocelli, viz., *M. polyphemus*, which is a native chiefly of the



FIG. 614. — *Acraea antiois*.

west coast, where it flies lazily over the glades and forest-like swamps of that district. This species is at present rare in collections. The Brazilian forms are mostly bright metallic blue above, brown beneath, with the ocelli arranged around the margins of the wings. They are, many of them, incomparably beautiful; and in their flight through the glorious tropical vegetation of the forests, they attract the eye of every traveller, and become to him one of the chief charms of his wanderings. Mr. Bates says: "It is a grand sight to see these colossal butterflies by twos and threes floating at a great height in the still air of a tropical morning. They flap their wings only at long intervals, for I have noticed them to sail a very considerable distance without a stroke. . . . *Morphos* are amongst the most conspicuous of the insect denizens of tropical American forests; and the broad glades of the Villa Nova roads seemed especially suited to them, for I noticed here six species. The largest species of *M. cisseis*

measured seven and a half inches in expanse. Another smaller kind, which I could not capture, was of a pale silvery blue color, and the polished surface of its wings flashed like a silver speculum, as the insect flapped its wings at a great elevation in the sunlight."

M. cpris, a prize long coveted by entomologists, has of late years been taken in considerable quantities in Bogota and Venezuela. The male of this fine species has the wings of a dazzling brightness, of a shade of blue to which no other epithet than that of "celestial" can be applied. The female, however, is of a dull yellow color, with markings of brown, and a bluish sheen. This sex is still extremely rare, and good examples are sold for enormous prices. *M. lertes*, common around Rio Janeiro, is of a very delicate shade of bluish white, with black markings on the costa. The most variable species is *M. achilles*, which passes



FIG. 615. — *Morpho neoptolemus*.

into no less than sixteen forms, known by as many distinct names. Thirty-five species of *Morpho* are known.

The next sub-family, Elymniinae, contains but one genus and twenty-six species. It is distinguished by having the wings very much produced at the apex, by the absence of ocelli, and by the curiously marked under surface of most of the species. They are inhabitants of the Old World, and many of them mimic the Danainae in color and general facies. The transformations of the genus have not been observed.

Placed next to the Danainae, by modern authors, is the extensive sub-family Satyrinae or "wood-nymphs," as they are familiarly called. They are for the most part

dull-looking insects of various shades of brown, the wings above and beneath adorned with ocelli, or eye-like spots of various sizes. "The larvæ are attenuate at the extremities, terminated by two anal points more or less prominent; head sometimes rounded, sometimes emarginate or bilobed, or surmounted by two spines. Chrysalis cylindroid, not much angular. Imago; palpi close, elevated, very hairy, body moderate, wings rather robust, abdominal edge of the secondaries forming a groove, discoidal cellule always closed, nervures of the primaries often much dilated at their origin." There are sixty genera and about seven hundred and thirty species, world-wide in their distribution, and generally found in considerable abundance. The caterpillars feed a good deal upon grasses, sedges, etc., and cannot be placed among the destructive insects. The tropical forms attain a large size, many of them measuring as much as five or six inches in expanse, though the bulk of the species are only moderate in size. In some



FIG. 616. — *Satyrus alope*.

South American genera (*Citharias*, *Hatera*, and *Pierella*), the wings are partially or wholly denuded of scales, and have an opalescent reflection. One of the species *Hatera esmeralda*, is thus alluded to by Mr. Bates: "It has one spot only of opaque coloring on its wings, which is of a violet and rosy hue; this is the only part visible when the insect is flying low over dead leaves, in the gloomy shades where alone it is found, and it then looks like the wandering petal of a flower."

Maniola (= *Erebia*) includes a large number of species, for the most part European, which are known as wood-browns, meadow-browns, etc. They are, as these familiar names suggest, for the most part brown in color, the ocelli of various sizes, with the lower side of the wings frequently ornamented with shades and streaks of white. Many of them are mountain insects, being only found at high elevations.

Eneis, better known as *Chionobas*, is a peculiarly interesting genus, which has the wings generally of a pale, livid, and, as stated by Morris, "diseased color, indicating its far northern habitat." They are chiefly lovers of mountains, though perhaps the most beautiful species of the genus, *C. iduna*, is found in the forests of Mendocino, California. Two or three of them inhabit Labrador, being the most common lepidopterous insects of that inhospitable country; and one very remarkable species, *C. argenteus*, a native of Chili, has the whole upper surface entirely silvered, looking like a piece of electroplate flashing in the sunshine. *C. scindea* has long been a favorite insect with North American entomologists. It is found upon the highest peaks of the White Mountains, New Hampshire, and in a few places on the Rocky Mountains. In some species of *Chionobas* the ocelli are almost or entirely obsolete.

Hipparchia and *Satyrus* are American and European, differing from kindred genera by the shape of the wings, by the venation, and by other details of structure. *H. persphone* and *H. semele* are well-known European species, while *H. ridingsii* is one of the very interesting forms of our own continent, having its home in the Coloradian portion of the Rocky Mountains. *Mycalesis* and *Ypthima* are composed of a number of thin-winged species, in which the ocelli are very large, so much so as at times to appear disproportionate to the size of the insect, which is rarely more than two inches in expanse. The genera are peculiarly Asiatic and Australian, *Y. aretous* and *M. terminus* being among the most common lepidoptera of New Holland. *Cononympha*

is well represented in the United States, one third of the total number being found amongst us. They are, however, peculiar to the western slope of the continent, *C. californica* and *C. galeactina* being extremely abundant in California and Oregon. *Neonympha* is found on the Atlantic coast.



FIG. 617. — *Neonympha eurtytis*.

The *Danainæ* comprise a large group of butterflies in which the wings are streaked with black, mostly along the course of the nervures, as in *Danaïs*, or are shaded with purple, and spotted with white, as in *Euphœa*. They are found all over the world, Asia, however, leading in point of numbers.

The genus *Hestia* is composed of very large insects, in which the ground-color of the wing is white or smoky, with the nervures broadly black, and with black spots variously distributed over the whole surface. They are all natives of the East Indian archipelago, and are very curious-looking insects. *H. itea* is the best-known species. It is about seven inches in expanse of wing. *Danaïs* is represented in this country by the well known *D. erippus* (= *D. archippus*), which is abundant everywhere throughout the United States, and which has gradually worked its way through the Hawaiian Islands to the Fijis, thence to the Friendly group, and finally to Australia, where it is said to be now quite abundant. The means of these migrations is scarcely known; but it is assumed that the insects make their long flight in crowds, from land to land, being probably kept upon their course by the aid of the wind. The caterpillar of the last-named species, with its yellow and black transverse bands, and its black filaments, and its beautiful chrysalis, looking like green ice spotted with gold, are well-known objects, while the perfect insect is, in summer, conspicuous upon every wayside, where its food-plants, the various species of *Asclepias* (milk-weed) are found. An admirable memoir on the anatomy of this butterfly has been published by Mr. Edward Burgess of Boston, which may be regarded as a text-book for the structure of the whole group. Several beautiful species of *Danaïs* are found in India and Australia, and one of these, specially worthy of remark, is *D. limniace*, which has been wrongly regarded as an *Euphœa*, and has been referred to by writers as *E. hamata*. This is the celebrated bugong moth of the natives of New Holland, so much prized by some of the tribes as an article of food. Dr. George Bennett, of Sydney, author of "Wanderings of a Naturalist in New South Wales," was the first to call attention to the singular facts connected with this insect, and we cannot do better than to give his own words. "The Bugong 'moths' (sic) collect upon the surfaces and also in the crevices of the masses of granite in incredible quantities. To procure them with greater facility the natives make smothered fires underneath those rocks about which they are collected, and suffocate them with smoke, at the same time sweeping them off, frequently in baskets-full at a time. A circular space is then cleared on the ground, on it a fire is lighted, and kept burning until the ground is considered to be sufficiently heated, when, the fire being removed, and the ashes swept away, the moths are placed upon the heated space, and stirred about until the down and wings are removed; they are then placed on pieces of bark and winnowed, to separate the dust and wings mixed with the bodies. They are then eaten, or placed in a wooden vessel and pounded by a piece of wood into masses, or cakes, resembling lumps of fat, and may be compared, in color and consistence, to dough made from smutty wheat mixed with fat. The bodies are large, and filled with a yellowish oil, resembling in taste a

sweet nut. . . . The first time this diet is used by the native tribes, violent vomiting and other debilitating effects are produced, but after a few days they become accustomed to its use, and then thrive and fatten exceedingly upon it." *Danaïs limniace* is at times quite common in the gardens of Sydney and Brisbane.

To India and Australia also belongs the great genus *Euploea*, in which the wings are generally marked with white spots, and adorned with purple or blue reflections. Many very fine and rare species are found in the little known islands of the Aru and Timor groups, and we are yearly adding others to our lists through the energy of collectors in those regions. Many genera of few species follow the *Euploea*s, most of which bear great resemblance to the *Heliconias*. Such are *Lycorea*, of which *L. elobea* is a familiar example, and *Diricoma kluzii*, a species with clear wings, marked along the nervures with bright brown streaks, common in Mexico and Central America. *Mechanitis* contains a group of rather large insects, in which the wings are comparatively narrow, the abdomen and antennæ quite long, with the prevailing colors yellow and shades of brown. The last three genera appear to replace the *Danaïads* and *Euploea*s in the New World, none of them being found away from the American continent.

Closely allied to them is a large group, natives of the tropical portion of the continent belonging chiefly to the genus *Ithomia*. These have the wings, with the exception of the margins, entirely destitute of scales, and when in flight appear as has been aptly said, like "spirit butterflies," their gauzy wings hardly giving the idea of active life. They are numerous both in species and examples, and no forest in tropical America can be searched without several being captured. They are not of large size, seldom exceeding three inches in expanse of wing, the colors of the borders being shades of brown, occasionally mottled with white or yellow. The denudation of the wing gives the idea of great weakness, but though in itself so beautifully thin and transparent, it is very tough and strong, and able to bear the dashing about among trees and flowers equally as well as those covered with scales. The genus contains upward of one hundred and sixty species already known to science.

The PAPILIONIDÆ may be characterized as follows: "Larva elongated, somewhat swollen anteriorly, tapering considerably to the posterior extremity, with two retractile tentacles on the segment behind the head. Chrysalis angular, supported by a girth around the centre. Perfect insect (imago) with the abdominal edge of the secondaries (hind wings) concave, and the discoidal cell closed. Hooks of the tarsi simple. Six well-developed feet in both sexes." The family is subdivided into two sub-families, the Pierinæ and Papilioninæ, but it is as yet an open question as to whether the Parnassiinæ should not be elevated to an equal rank, the singular pouch possessed by the females, the fact of their weaving a slight cocoon in which to undergo their transformations, the short antennæ, and many details connected with their habits and economy, seeming to point to the conclusion that they should be separated.



FIG. 618. — Larva of *Papilio*.

First we approach a sub-family of great extent, and from the destructive habits of the larvæ of many of the species, of immense importance in the economy of nature, including the insects known as the 'garden white,' 'cabbage white,' etc., and by science called the Pierinæ. It contains twenty-nine genera, and about eight hundred species, and is distributed in one or other of its forms over the world's surface. This sub-family may be thus described: "Larva slightly pubescent, somewhat attenuated

at the extremity. Imago with the abdominal edge of the secondaries without a concavity. Discoidal cellule closed. Hooks of the tarsi unidentate."

Colias is one of the most widely spread genera, though for the most part confined to the northern hemisphere, only a very few species being found south of the equator. The great resemblance which many of the forms bear to each other has occasioned a good deal of discussion as to their relative specific value, and *Colias* may be regarded as a bone of contention among naturalists, though nothing but breeding from the egg through successive generations will settle many of the points in dispute. Like many of the following genera, the colors are shades of yellow with black borders and spots, and the caterpillars are green, feeding on *Trifolium*, *Astragalus*, *Melilotus*, and kindred plants. The most common species in the



FIG. 619.—*Colias philodice*.

United States is *C. philodice*, which is familiar to every schoolboy throughout the country. It passes into other forms as we go west, and many entomologists are to be found who think that *C. eriphyle*, *C. christina*, and *C. occidentalis*, are but local varieties of the common species. Like *Callidryas*, species of *Colias* have been met at great distance from land, and Mr. Darwin gives an inter-

esting account of one of these flights, observed by him: "One evening, when we were about ten miles from the Bay of San Blas, vast numbers of butterflies in bands or flocks of countless myriads, extended as far as the eye could range. Even by the aid of a telescope it was not possible to see a space free from butterflies. The seamen cried out 'it was snowing butterflies,' and such in fact was the appearance. More species than one were present, but the main part belonged to a kind very similar to, but not identical with, the common English *Colias edusa*. The species was probably *C. lesbia*."

Meganostoma, which by some authors is united to the last genus, contains one of the most beautiful insects of the whole sub-family. This is *M. eurycle*, which has the wings bright orange with a black border, over the whole surface being spread a brilliant purple sheen. The female is pale yellow, with little of the beauty of her partner. The species is a native of California, where the caterpillar feeds upon a papilionaceous plant of the genus *Amorpha*. *Gonepteryx* is a grand genus of few species, in which the wings are falcate at their apex, the veins swollen and distinctly thickened, especially at their base, while the lower side of the wings is wrinkled like a leaf. Two very large species are natives of Mexico, viz., *G. clorinde* and *G. marula*. The former white, with a large orange patch; the latter bright citron, with a very conspicuous black discal dot. *G. rhamni* is a well-known European species, while the more beautiful *G. cleopatra* extends into Africa and Asia Minor.

The genus *Catopsilia* (= *Callidryas*) contains a number of very showy insects, mostly of various shades of yellow. It occurs in the Old and New World, not a few being found in India and Australia, while North and South America boasts of at least twenty-five species. The most showy of these is *C. phileia*, in which the wings are of a bright golden yellow, with a large deep orange patch upon the costa. It is a large insect, four to five inches across the wings, and frequently occurs in great quantities from Mexico to Brazil. They often congregate in large numbers, and Mr. Bates speaks of seeing so many at rest with the wings erect on the shoal of a muddy river, that, "as they swayed about in the wind, they looked like a large bed of crocuses in

full bloom." Not one of the least singular habits of these butterflies is that of their migrating from place to place, and being often found far out at sea in immense numbers.

The most common species of this country is *C. cubile*, which ranges from New York to Florida, thence extending through Mexico as far south as Patagonia. It is of a bright citron yellow, of a very pure and clear tint, and is a very striking object when on the wing. It is occasionally abundant along the New Jersey coast, particularly about Long Branch, and has also been taken on Staten Island. The caterpillars of *Callidryas* are nearly always green, while the chrysalis is very much widened and flattened out in the middle like the deep keel



FIG. 620. — *Callidryas phlox*.

of a boat. The great genus *Pieris* next engages our attention. It contains about one hundred and forty species, the bulk of which are natives of the northern hemisphere. They are nearly all white, with shades and patches of black, the under side of the wings more or less shaded with yellow. In this country are eleven or twelve distinct species, one of which, at least, and the most destructive, is an importation from Europe. This is *P. rapæ*, which of late years has increased in the United States to such an enormous extent as to be a serious pest to the farmer and gardener. It is so abundant as to be rapidly overshadowing one or two other species formerly quite common, and it is feared that, unless very strenuous measures be adopted to check its ravages, this species will, in a few years, overrun the entire continent. Luckily it is well known, and the caterpillar can, by watchfulness and attention, be gathered in large quantities and destroyed. It is needless here to do more than briefly allude to the parasites which keep it in check, or to the energy displayed by our various agricultural societies in combating this insidious foe.



FIG. 621. — Chrysalis of *Pieris rapæ*.

Some idea of its depredations may be gained from the statement that the loss of cabbages and kindred plants by this species in the state of New York alone amounts yearly to several thousands of dollars.

Another species of destructive habits, but less abundant than *P. rapæ*, is *P. oleracea*, "which feeds on various plants besides cabbage, such as broccoli, cauliflower, turnip, radish, and mustard," and is popularly known as the pot-herb butterfly. The larvæ of this species are dull green, covered with a very fine pubescence. *P. protodice* does some damage also to garden plants, but is found more sparingly than the other two species, though it extends its range quite across the continent, being in some seasons abundant in California. *P. brassicae* and *P. napi* are also determined enemies of the agriculturist, and



FIG. 622. — *Pieris oleracea*.

are regarded in Europe as being among the list of his greatest insect enemies. Some of the South American species are very beautiful, and have the lower wings on the under side marbled with black and yellow. Such are *P. protodice*, and *P. xanthodice*; while *P. crategi* and *P. hippia* represent a group in which the white wings are very distinctly marked with black along the course of the nervures.



FIG. 623. — Chrysalis of *Terias*.

The genus *Eurema*, better known as *Terias*, is of considerable extent, one hundred and fifteen species having been described. They are nearly all of various shades of yellow, from pale lemon to the deepest orange, with black borders of various widths and patterns, and are found in all parts of the globe, excepting Europe. Some of them are very beautiful, the rich orange field strongly contrasting with the black margins. We have eight species in our lists as natives of the United States, the most striking of which are *T. nicippe* and *T. proterpia*. The former of these is

quite common in the southern states, and sometimes travels as far north as New York, while the latter, though very abundant in Mexico, has only, as far as our territory is concerned, been taken in Arizona. *T. lisa* is remarkably common over a great portion of the northern and eastern states, and may sometimes be seen in almost countless numbers wherever its food plant, *Cassia chamaecrista* happens to grow. It is citron yellow, with narrow black borders, and is one of the smallest of our butterflies. The caterpillars of the genus are mostly green, with various stripes of white or yellow.



FIG. 624. — *Terias lisa*.

A very curious insect belonging to this group, which undergoes its transformation in a community, — a large flask-like nest serving as the home of the whole brood, — inhabits the table-lands of Mexico, and has been described by Professor Westwood under the name of *Eucheira socialis*. The nest is parchment-like in its texture, is about eight or ten inches in length, and is suspended from the branch of a tree, somewhat after the manner of many wasps. Instances of Lepidoptera living thus in families are extremely rare among the butterflies, and the present species is consequently of considerable interest. The imago is blackish-brown, with paler bands and streaks, and bears great resemblance to some species of the Heliconidae. Allied to this is another genus, containing many species, called by Hübner *Dismorphia*, and, afterwards, by Dalman changed to *Leptatis*. The former name, however, generally holds among naturalists. The species are variously colored, shades of yellow, brown, and greenish being most apparent among them. The great peculiarity in their history is their mimicry in form and colors of the species belonging to a totally different group, viz., the before-mentioned Heliconidae. These latter insects are, as we have seen, a sub-family of the Nymphalidae, and are distinguished by the secretion of an acrid and offensive fluid, which protects them from the attacks of birds and other enemies. The species of the genus *Dismorphia* which imitate them are found in company with the *Heliconias*, and resemble them so much in color and form that among a number of individuals they are hardly to be separated without very careful observation. Darwin says: "From the fact that the Heliconidae are colored in their usual manner, while the others depart from the general coloring of the groups to which they belong, it is clear that the latter are the imitators and the Heliconidae the imitated. Mr. Bates, therefore, infers that

the butterflies which imitate the protected species had acquired their present, marvelously deceptive appearance through variation and natural selection, in order to be mistaken for the protected kinds, and thus to escape being devoured."

The true *Parnassius* may be characterized as having the "antennae very short, the wings of a parchment-like texture, occasionally denuded of scales, the abdomen very stout and hairy, furnished in the females of nearly all the genera with a singularly formed corneous pouch, the larva smooth, thick, cylindroid, with small tubercles, slightly hairy, with a Y-shaped furcate tentacle on the first segment, the chrysalis powdered with bluish efflorescence, enveloped in a light tissue of silk, and sustained by transverse threads."

The genus *Parnassius* has the wings mostly white, tinted occasionally with yellowish, in one very rare and beautiful species, *P. eversmanni*, the ground color being bright lemon-yellow. The ornamentation is composed of crimson spots of various sizes, generally surrounded by black rings, and occasionally with a white pupil, and on the margins black blotches of various shapes and sizes. One section of the genus wants the red spots, and herein approaches the *Pierinae*, especially those forms nearest to *P. crataegi*. The *Parnassians* are all lovers of mountain regions, and are rarely found below fifteen hundred feet elevation, while their range is confined to the northern hemisphere, none of them having been found south of 28° of north latitude. The best-known species is *P. apollo*, which is abundant throughout Switzerland, the Pyrenees, and the Cévennes, being found, though rarely, in Sweden and Norway. *P. phobas* is also found in the Alps, and its varieties or offshoots extend through the Ural Mountains and the Altai, to Kamschatka, one of them crossing Behring's Straits, and making its home in the Rocky Mountains, where it is very abundant, having been described as *P. smintheus*. A variety, in which the spots are yellow instead of red, and which has been known as *P. behrii*, is peculiar to the Sierra Nevada and the coast range of California. I have said in another place: "It is a remarkable fact that *P. behrii* (always with yellow spots) is found in California, occasionally in large numbers, while no example of the typical *P. smintheus* (with red spots) has as yet been met with within the borders of that state. It may therefore be reasonable to conclude that, in the migration of the species known as *P. smintheus*, certain individuals, a little differing from the type, divided themselves from the main body, and passed down the mountain chain of the Sierra into California, here meeting certain conditions, as yet only vaguely known to us, which tended to the development of yellow rather than red spots, at the same time eliminating some of the black patches on the wings of the typical form, and producing the examples which we now recognize under the name of *P. Behrii*." Three other species are known to inhabit this continent. Altogether about thirty-five species of the *Parnassius* are now known.

To the *Papilionine* belong some of the giants of the butterfly world, forms which not only attract the eye by their beauty, but astonish by their size and by their powers of flight. First we have to consider a group of insects which are associated under the generic name *Papilio*. But it must be confessed that this contains some very incongruous forms, and needs careful revision, and, above all things, a study of the earlier stages. Jacob Hübner began the work of separating the genus about the beginning of the present century, and has been followed in this country by Mr. S. H. Sender, who has assigned our North American species to not less than six genera, all of which, according to the last-named author, are of equal independent value. However Mr. Sender's conclusions may be contested, it is certain that the larvae as well as the

perfect stages differ in such important particulars as to call for their separation; and to unite in one genus the *Ornithoptera*, having larvæ bearing long, fleshy spines, and which are suspended in chrysalis by the tail as well as supported by the central girth, with the smooth larvæ and long-tailed imagines of our *P. turnus*, *P. gjae*, etc., is at least contrary to the practice which prevails with reference to other groups.

One of the grandest species, as far as its size is concerned, is *P. antimachus*, a native of the west coast of Africa, where it flies in the hottest sunshine, thus probably often escaping capture, as few Europeans can bear the terrible heat of the middle of the day in the region it inhabits. At present it is an exceedingly rare insect, only about fifteen specimens being known to exist in collections, the first example having been brought to England near the close of the last century and sold to Mr. Francillon for a very high price, passing at his death into the hands of the Honorable Alexander Macleay of Sydney, for the sum, it is said, of £150. This specimen (the type) is now in the magnificent collection of the present distinguished entomologist Mr. William



FIG. 625. — *Papilio turnus*.

Macleay. It is about eight inches in expanse, rich brown in color, streaked and otherwise marked with black, being by no means as handsome and attractive as many of its congeners.

The species of *Papilio* inhabiting this country are mostly furnished with long tails, those which are the most common being known as *P. turnus*, *P. troilus*, and *P. asterias*, these being found nearly throughout the country east of the Rocky Mountains. On the western slope they give place to other forms, *P. rutulus* and *P. eurymedon* taking the place of *P. turnus* and *P. indra*, and *P. zolicaon* that of *P. asterias*. The caterpillars feed on a variety of plants—*turnus* and allies on cherry, sassafras, willow, etc., while *asterias* and its relatives prefer those of the natural order Umbelliferae. They are mostly shades of green, with various markings of black and yellow, with spectacle-like marks on the third and fourth segments, and with the retractile horns bright orange. In the southern states *P. palamedes* is abundant, the caterpillar doing occasional mischief to the young orange trees; and another species, *P. polydamas*, whose home is apparently the West Indies and Mexico, is found, though rarely, in Florida.

Our beautiful *P. ajac*, with its numerous varietal forms, has wide distribution through the states, having been taken from New York to Texas, and westward as far as the Mississippi valley. It is well known to lovers of nature, its greenish-white wings, streaked or striped with black, with a bright patch of crimson at the anal extremity of the lower pair, rendering it a very conspicuous object. The caterpillars feed upon *Asimina triloba* (papaw), and in their outline and color are somewhat similar to those of the more familiar *P. turnus*. *P. daucus* is a very fine insect, closely allied to *P. turnus*, in which the secondaries have three tails. It is found in California, Arizona, and various parts of Mexico. Twenty species, or at least strongly marked forms, of true *Papilio* may be credited to the United States.

Throughout the tropical regions of the American continent is found, in large numbers of individuals, a group of species remarkable for the black velvety ground-color of the wings, with red, green, and purplish blotches upon them. They are very beautiful insects, and notable from the fact that the sexes differ so considerably as to have been, in frequent instances, described by eminent entomologists as distinct species. The caterpillars are various shades of green and brown, with bands and stripes of yellow, red, and blue; the fourth, fifth, and sometimes the sixth segments elevated into a hump, and armed with variously-formed protuberances. Probably of this group at least forty species are now known.

In another section of the New World *Papilios* the hind wings have a very sharp, narrow, long tail, while their colors are various shades of orange and yellow, and still another large group, numerous both in species and individuals, has the wings clear or greenish white, striped with black, with a few red or yellow spots on the margin of the lower pair. It may be said that nearly one hundred and fifty species of true *Papilio* are already known as natives of various portions of the American continent.

Many grand species are found in Africa, and especially upon the west coast, one of the most striking being *P. zalmoxis*. This fine insect is very aberrant in its color, the ground of the wings being bluish gray with black stripes, in general facies approaching the Danaidae, while the under side of the hind wings is bright tan color, and the body dull orange. It is over eight inches in expanse, and must be a very conspicuous and striking object in its native forests. Nothing is as yet recorded as to its early stages. *P. hesperus* is also another superb insect from the same region. It is jet, velvety black, with pale yellow blotches, and with rather long but broad tails. *P. niveus* is a species in which the black ground-color of the wings is relieved by a bright sea-green macular band common to both, while its allies, *P. epiphorbus* and *P. phorbanta*, have the same system of coloration differently arranged.

But after all, as far as the Old World is concerned, the bulk of the species composing the genus under consideration are to be found in various parts of Asia; the Himalayas and the Malay Islands yielding the largest supply. One of the most striking groups is that comprising the common Indian species, *P. ganesa*, *paris*, *brama*, and *bianor*. These are, for the most part, golden green, the wings covered with metallic irrorations, and variously marked with reddish or purplish spots on the margins. They are magnificent insects, their colors being perfectly dazzling in the sunshine. *P. crino*, *P. krishna*, and *P. arjuna*, are among the rarities of this group, and vie with their relatives in richness and beauty of color. Another striking section of the genus is represented by *P. ulysses*, in which the wings are of the most dazzling metallic blue, with broad black borders, recalling very much the coloration of the gigantic *Morphos*, insects belonging to a very different family. The *ulysses* group is

found in Amboina, and others of the East India islands, extending in modified forms or varieties to Australia. Closely related species, distinguished by the same brilliancy of color, are peculiar to the Molucca Islands. The butterflies of which *P. rhetenor* and *P. protenor*, are representative examples, are remarkable for the great prolongation of the hind wings, which are narrow, deeply indented, sometimes with long tails, and strongly marked with blood-red spots on the margins. They are, for the most part, very large and showy insects, and are natives of the northern portion of India, as well as of China and Japan. A species from the latter country, *P. alcinous*, is remarkable for the color of the female, which is fawn drab, with orange markings, while the male is black, with red markings on the margin.

The various portions of Australia cannot be said to be rich in the species of *Papilio*, only seventeen species having as yet been recorded from that continent, but five of which seem to be peculiar to it, the remainder being stragglers from the East Indian and Malayan regions. One of the remarkable forms is *P. erectheus*, a large and



FIG. 626. — *Papilio alcinous*.

showy species, in which the sexes differ considerably, the male being black in ground color, while the female is brownish white, with wide black borders, marked with orange dashes and spots. It is a very common insect in the warmer parts of Australia, and is frequently seen flying in the streets of Sydney, the caterpillar being at times very destructive to orange plantations.

P. sarpedon, with its wings profusely marked with bright blue green, is a very striking object in the gardens and plantations of New Holland, and is one of the species delighting in almost perpetual flight, selecting some open sunny space, and traversing this backwards and forwards for hours with singular pertinacity, rarely alighting, or, if so, only for a moment, arising again at the slightest disturbance, and gliding rather than flying over the spot it has selected for its playground. It is a widely distributed species, reaching throughout India to China and Japan.

Europe claims but four species of *Papilio*: viz. *P. machaon*, *P. podalirius*, *P. alexanor*, and *P. hospiton*. The first named of these is the most common, and is found in some portions of Germany and France in considerable numbers. Its cater-

pillar feeds on umbelliferous plants, and at one time it was rather abundant in the fens of Cambridgeshire and Lincolnshire, England; but, from the drainage of those districts, it has there become quite rare. A modified form of the species has been taken in Alaska and British Columbia, and is known as *P. alaska*. *P. podalirius* is chiefly found in the warmer parts of France. *P. alexanor* has its home about the lower Alps, and *P. hospiton*, by far the rarest of the four species, is only taken in the islands of Corsica and Sardinia. The prevailing colors of the European species are



FIG. 627. — *a*, *Leptocircus curius*. *b*, *Ornithoptera ampheryxus*, larva and chrysalis.

shades of pale yellow with black markings. Up to this time over three hundred and fifty species of the genus *Papilio* are known.

By almost common consent, at the head of the Papilioninae are placed the glorious *Ornithoptera* of the tropics, and from their size and beauty they well deserve this position. But it should be stated that in the chrysalis state these magnificent insects unite the characters of the Suspensi and Succineti, not only binding a thread partially around the body, but also suspending themselves by the tail, thus evidencing a slight approach to the Nymphalidae.—another proof, if it were necessary, that the objects of creation can by no means be arranged in straight lines. This habit of the chrysalis,

however, carefully and ably described by Dr. Horsfield, seems to be sufficient to separate the two genera of *Ornithoptera* and *Papilio*, though by many entomologists they have of late been united. Of the former genus, as at present restricted, there are sixteen species, exclusive of many varietal forms, which have received distinct names. They are mostly in color grand combinations of green and black, orange and black, purple and black, and bright yellow and black, and measure on the average about seven inches in the expanse of the wings. *O. cræsus* has the wings the richest golden orange instead of green, and when in flight is said to be almost dazzling to the eye. Fine specimens are extremely rare, and command very high prices for the cabinet. It is a native of the island of Batchian; and Mr. Wallace's account of its capture is so entertaining that it may well be copied at length: "During my first walk into the forest at Batchian, I had seen sitting on a leaf, out of reach, an immense butterfly of a dark color, marked with white and yellow spots. I saw at once that it was a female of a new species of *Ornithoptera*, or 'bird-winged' butterfly, the pride of the Eastern tropics." Mr. Wallace was subsequently fortunate enough to secure a female, "and the day afterwards a fine male. I found it to be as I had expected, — a perfectly new and most magnificent species, and one of the most gorgeously colored butterflies in the world. . . . The beauty and brilliancy of this insect are indescribable, and none but a naturalist can understand the intense excitement I experienced when I at length captured it. On taking it out of my net and opening its glorious wings, my heart began to beat violently, the blood rushed to my head, and I felt much more like fainting than I have done when in apprehension of immediate death. I had a headache the rest of the day, so great was the excitement produced by what will appear to most people a very inadequate cause.

Fragile as are the wings of the beings we have been considering, it will perhaps surprise many who have not investigated the subject, to learn that butterflies exist in a fossil state, and that the delicate creatures which now give such animation to our woods and fields sported their short life of activity and freshness away back in the tertiary period.

HENRY EDWARDS.

ORDER XI. — HYMENOPTERA.

THE order Hymenoptera includes the bees, wasps, ants, ichneumon-flies, gall-flies, saw-flies, and allied insects. Many of these are well known to every observer. They are among the first of insects to attract attention, and it is only necessary to cite the popular names given above to convey a general idea of the more important characters of the order. In structure they occupy a high place in the class Insecta. By many entomologists they are now placed as the highest of insects; and if the development of their instinctive powers alone is considered there can be no doubt that they are entitled to this rank. The marvellous intelligence of bees, wasps, and ants has attracted the attention of men of all times.

The more important characters of the order may be briefly stated as follows: The mouth-parts are formed both for biting and sucking. There are four wings, which are membranous, and have comparatively few veins. The second pair of wings is always smaller than the first. The abdomen in the females is armed with a multivalve saw, ovipositor, or sting. The metamorphosis is complete; that is, the adult insect does not resemble the larva in form.

In the Hymenoptera the head is freely movable, and usually bears, in addition to the large lateral compound eyes, three ocelli, which are arranged in a triangle on the vertex. In many cases the ocelli are wanting; and a few members of the order are blind. The blind species are mostly ants which live in dark places. It is said also that certain Chalcid-flies are blind. The antennæ are variable in form in the lower of the two sub-orders (Terebrantia) into which this order is divided. The number of segments varies from three in certain saw-flies (*Hyloptoma*), to sixty in some of the Ichneumonidæ. The general form of the antennæ may be long, thread-like, short and clubbed, or even pectinated. In some species they are smooth, in others hairy. Often those of the males are more developed than those of the females. In the higher of the two sub-orders (Aculeata) the antennæ are usually filiform, or setaceous and simple, and almost uniformly composed of thirteen joints in the males and twelve in the females.

The mouth-parts are very highly developed. With other insects the mouth is fitted either for biting or for taking liquid food only. But the members of this order can both bite and suck. The labrum and mandibles are essentially the same as with other biting insects. In many species the mandibles are very powerful, enabling the insects to perform wonderful feats, even to piercing long tunnels in solid wood. With these insects the mandibles are used much more as tools to aid in building and provisioning their nests than they are as organs for chewing food. The maxillæ and labium vary greatly in form in the different families. In the more typical members of the order these organs are greatly elongated, and form a kind of sheath for the labium and its appendages. In this case the labium and maxillæ together constitute a complicated apparatus for the collection of liquid food.

The most obvious characteristic of the wings is the membranous texture which

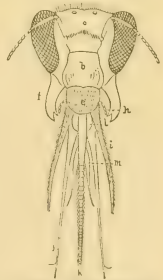


FIG. 628. — Mouth parts of a bee. *b*, clypeus; *c*, labrum; *f*, mandibles; *h*, maxillary palpi; *e*, maxillæ; *d*, labial palpi; *g*, ligula; *l*, palpafer; *m*, paraglossæ.

gives the name to the order (*umen*, membrane; *pteron*, wing). The wings are either naked or covered with fine microscopic hairs. They are usually transparent, sometimes clouded, and frequently they are iridescent. The veins are comparatively few in number. In special works on Hymenoptera each of the veins of the wing and each of the cells or spaces circumscribed by the veins is given a distinct name. It is not, however, worth while in this place to enumerate these names.

The front wings are larger than the hind ones. Each front wing has a thickened spot near the lateral extremity of the front margin. This is the stigma, and is represented by the shaded portions in our figures. The two wings of each side are united during flight by a series of minute hooks on the front margin of the hind wings. These hooks catch the hind margin of the front wings, so that the two wings present a continuous surface.

As in all the other orders of insects we find here species which are destitute of wings; and there are species in which one sex is wingless and the other winged. While with the ants the males are winged, the sterile females (workers) are wingless; and the fertile females (queens) have wings at first, but shed them after the occurrence of the flight, in which the pairing of the sexes takes place.

The legs are generally long and slender, with five-jointed tarsi. Various modifications of form will be noted later. The form of the abdomen varies to a remarkable degree. It may be joined to the thorax by a slender pedicel or by nearly its entire width. It may be composed of short and very broad segments, or of long and slender joints. Between these extremes there are all gradations. Figures of the more important modifications will be given in connection with the various families. In the females the caudal end of the body is furnished with a complicated apparatus known sometimes as a sting and sometimes as an ovipositor. In the higher families it is a sting, and is connected with a poison gland. In the lower families it is of many forms. In some species it is a multivalve saw fitted for cutting slits into leaves for the insertion of eggs. In others it is a boring instrument by which a deep circular hole can be made in solid wood. Again the different parts of which it is composed merely serve to guide the eggs to the desired place during oviposition.

In their transformations the Hymenoptera undergo a complete metamorphosis, the form in which they first appear on leaving the egg being very different from that they assume in the adult state. The eggs of the Hymenoptera present little that is remarkable in form or coloring. Usually they are longer than broad, with rounded extremities, and with a thin smooth shell, which is rarely colored. Certain parasitic species fasten their eggs to other insects by means of stalks. In some members of the order the eggs swell before hatching until they are nearly or quite twice the size that they were when first laid. The number of eggs laid by a single female varies greatly; with some of the solitary species it is probably not more than ten or twelve, while with the social species it may be more than the same number of thousands.

In the two lower families the larvæ are furnished with legs, and frequently have a striking resemblance to caterpillars. Like the larvæ of Lepidoptera these aberrant forms feed upon leaves or bore into the woody portions of plants. But in the other families the larvæ are footless, maggot-like creatures, incapable of any extended motion, and entirely dependent on the instinctive care of the adult insects. To a certain extent this dependence is also true in the case of the lower families, for if the parent saw-fly were not to lay her eggs upon the proper kind of plant the larvæ would starve. In the higher and more typical members of the order the care exercised over

the helpless young by the adult insects is something truly marvellous. In some of the families this merely consists in placing the egg in the proper situation. It may be in the substance of a leaf, or twig, or branch, where an abnormal vegetable growth will take place, within which the larva can live and find nourishment; it may be either upon or within the body of another insect upon which the larva is to live parasitically; or, again, within the nest of some other insect, from which the larva can sponge its living. In each of these cases the instinctive care of the parent is of a higher grade than would appear at first sight. With the gull-making species it is necessary that the egg be laid in a particular part of the proper food plant. Each parasitic species infests only certain other insects, and no more eggs are laid within or upon the parasitized insect than can be fully developed. With the guest insects the egg must be laid in the proper nests, else they, or the larvæ which hatch from them, will come to grief. All these, however, are simple exhibitions of instinct compared with what we find in several of the higher families. Here a nest, often very elaborate in construction, is prepared for the reception of the egg. And then either a store of food sufficient to bring the young insect to maturity is placed with the egg in this nest, or the wants of the young receive daily attention. What is perhaps more wonderful than anything else in this connection is the fact that with many species this care of the young is not given by either of the parents, but by other individuals which are sterile. These individuals bear a certain relation to the young under their care, which has been aptly expressed as that of maiden aunts. It is an interesting fact that these helpless footless larvæ are developed from embryos which at a certain stage possess legs. This indicates that the legs have been lost through disuse, and that these insects are the descendants of those which possessed legs in their larval state.

When the larvæ are full grown they transform to inactive pupæ, which have all the limbs of the perfect insects enclosed in distinct sheaths, and folded upon the ventral aspect of the body. With many species the larva, before transforming, spins a cocoon about its body. With some this cocoon is composed of comparatively loose silk, and resembles to a certain degree the cocoon of a lepidopterous insect. In others the cocoon is of a very dense parchment-like texture; and in still others it resembles a very delicate foil.

The adult insects are usually very active creatures. In this state as a rule they take but little nourishment, and this consists almost entirely of the nectar of flowers and the sweet excretions of plant-lice and bark-lice. Hymenoptera may be seen constantly collecting food from flowers or destroying and carrying off other insects. There are, however, some species, notably ants, in which the adult state may last many years, during which time they are constantly active and require considerable food.

As with other insects it is the rule in the Hymenoptera that the union of two sexes is necessary to reproduction. Still instances of parthenogenesis are common throughout the entire order. Many make sounds. The humming of the bees is familiar to all. Landois has studied these sounds and the apparatus by which they are produced. In the hive-bee a sound is produced by the vibration of the wings during flight; but the true voice of the insect is produced by the band-like margins of the stigmata, both thoracic and abdominal. In the bumble-bees the abdominal stigmata are here the chief producers of sound, and they present a rather complicated construction. Each stigma is an oval aperture surrounded by a chitinous ring; it is situated beneath a hemispherical cup divided by a slit into two nearly equal parts, and is furnished with

a double chitinous membrane stretched between the stigma and the lower half of the cup. It is by the vibration of these parts that the well-known hum is produced.

The Hymenoptera are divided into two sub-orders, the Terebrantia or borers, and the Aculeata or stingers. In the Terebrantia the caudal end of the abdomen is furnished with an instrument employed as a saw or borer for depositing the eggs. In the Aculeata the end of the body is furnished with a sting which is connected with a poison gland. The antennæ of the males usually have thirteen segments, and those of the females twelve. The Terebrantia are lower in rank, both structurally and in intelligence, than the Aculeata. Gerstæcker has pointed out an important structural difference between the plant-eating Hymenoptera and the higher and more typical forms. In the latter, or true Hymenoptera, the first abdominal segment of the larva, during development, becomes transferred to the thorax, so that in the abdomen of the adult we can never distinguish more than eight dorsal half-segments. In the phytophagous Hymenoptera this segment is retained in the abdomen, in which nine segments are recognizable in the adult.

SUB-ORDER I. — TEREBRANTIA.

In following out the plan of this work, it is necessary to discuss the Terebrantia before we study the Aculeata. On some accounts this is undesirable, as the Aculeata consist of the more typical forms, while the lower members of the Terebrantia are anomalous both in structure and habits. Therefore, if the reader be not on his guard, he will at first get a wrong impression respecting the characters of this order.

The Terebrantia has been divided into three sections, the Phytophaga or plant-eaters, the Gallicola or gall-inhabiters, and the Entomophaga or insect-eaters. To the first section belong two families, the Tenthredinidæ and Uroceridæ. The second section consists of a single family, the Cynipidæ. And to the third section five families belong, the Chalcididæ, Proctotrupidæ, Braconidæ, Ichneumonidæ, and Evaniidæ.



FIG. 629. — LARVA OF *Lyda*.

The TENTHREDINIDÆ includes the insects popularly known as saw-flies. They are of great interest to the systematist on account of their aberrant characters. They show some striking affinities to the Lepidoptera. In the adult the base of the abdomen is joined broadly to the thorax as in Lepidoptera, instead of being constricted so as to form a waist as in the more typical Hymenoptera. The head is broad and the thorax wide, closely resembling that of Lepidoptera. The larvæ are like caterpillars both in appearance and habits. Like them, they have a more or less cylindrical body furnished with six true legs and a number of prolegs, and they also feed on the leaves of plants. The larvæ of saw-flies

have, however (except in the genus *Lyda*), from twelve to sixteen prolegs; while caterpillars never have more than ten.

When full grown, the larvæ make parchment-like silken cocoons. Sometimes these are attached to the plant upon which the larvæ have been feeding, but more often the larvæ descend to or beneath the surface of the ground before transforming. When the adult insect emerges it lays its eggs upon the plant upon which its larvæ are to feed. Sometimes these eggs are simply placed upon the surface of the plant;

in other cases slits are made into the leaves or other parts, and the eggs laid in these slits. The slits are made by the peculiar ovipositor of the female. The principal part of this organ is a pair of saw-like blades, which suggest the popular name of the family.

Selandria rosæ, the rose slug, is an insect known in its larval stage to all florists. The imported currant-worm, *Nematus venetricosus*, and the native currant-worm, *Pristiphora grossulariæ*, are also well known members of this family.



FIG. 630. — *Selandria rosæ*.

The family UROCEIDÆ, or horn-tails, includes insects which are quite closely allied to the saw-flies, but which differ from them in certain characters, especially in the structure of the ovipositor or borer, and in the form and habits of the larvæ. The body of the adult is elongated and nearly cylindrical in form. This is well shown in *Sirex gigas*. The male is furnished with a prominent horn at the caudal end of the



FIG. 631. — *Sirex gigas*, male and female.

abdomen, which suggested both the popular and the scientific names of the family. The ovipositor of the female is attached near the middle of the ventral surface of the abdomen and extends far beyond the caudal end of the body. The principal part of the ovipositor consists of a boring apparatus by means of which the female insect can drill a hole into solid timber. These insects may often be found during the summer months boring holes into living trees, in which they lay their eggs.



FIG. 632. — *Tremex columba*.

The larvæ are wood-boring and often do great injury to trees, the trunks of which they perforate. They have six very small true legs, but no prolegs. When fully grown they make cocoons of silk in their burrows, interwoven with little chips which they have made. After the pupal skin is cast off, the winged insect breaks through its cocoon, creeps to the mouth of its burrow, gnaws through the

covering of bark over it, and comes out of the tree into the open air. *Tremex columba* has similar habits and often does considerable damage to shade trees.

The family CYNIPIDÆ comprises forms known as gall-flies. In these the abdomen is usually furnished with a short peduncle and is much compressed. The second or the second and third segments (the first forms the peduncle) are greatly developed. The remaining segments (usually five in number) are short, and each is more or less covered by the preceding segment. Concealed within these segments is the long, partially coiled, very slender ovipositor, which arises near the base of the abdomen. The wings of the gall-flies have comparatively few veins, and the fore wing lacks the stigma; some forms are wingless. The antennæ are not elbowed, and consist of from thirteen to sixteen joints. The larvæ are maggot-like, and without caudal opening to alimentary canal.

These insects are termed gall-flies because the majority of the species live within galls. But the student must bear in mind that not all the species of this family are developed in galls, and that not all galls are produced by members of this family. A

gall is an abnormal vegetable growth caused by an insect, and within which one or more insects live and derive their nourishment. The common oak-apples are familiar examples of galls.

If one of these galls be cut open at the proper time, there will be found at the centre a cell containing a grub-like larva. This larva derives its nourishment from the substance of the gall. Many galls are compound, a large number of cells being united to form a single gall. The mossy rose-gall, so common on the wild rose, is an illustration of this.

Many species of gall-flies undergo their transformations within the gall; while in other species the full-grown larva leaves the gall and enters the ground to transform. Each species of gall-fly infests a special part of one or more particular species of plants. And the gall produced by each species of insect is of definite



FIG. 633. — Gall of *Rhodites roseæ* on wild rose.

form. Thus, when an entomologist who has studied these insects sees a familiar gall, he knows at once what species of insect produced it.

The manner in which galls are produced has been the subject of much speculation. The female gall-fly, as already stated, is furnished with an ovipositor. By means of this instrument she punctures the surface of that part of the plant where the egg is to be laid. Now it has been supposed that at the time the egg is laid there is propelled into the wound of the plant a small quantity of an irritating fluid, the action of which upon the plant in some way causes an abnormal production of cellular tissue. On this hypothesis the differences between the galls of different insects was explained by supposing that the fluid produced by each species of insect had peculiar properties. It has been shown that in many cases this cannot be true. It is, however, still held for certain insects. Thus, the wound made by a certain saw-fly (*Nematus vallesnerii*) in the leaves of *Salix amygdalina* "causes an abundant formation of cells, and the gall thus formed attains its full growth at the end of a few days, before the larva has escaped from the egg." "In the Cecidomyidæ, on the contrary, the manner in which the eggs are laid show clearly that it is the larva which causes the formation of the gall. The same is the case with the Cynipidæ. No effect is produced until the larva is hatched. *Trigonaspis crustalis* lays its eggs in May, and the larvæ do not hatch

till September; and it is only in this last month that the gall begins to form. As soon as the larva has attacked some cells the increase is effected. Mr. Adler (of Schleswig) has even proved that whilst the young larva has the hind part of its body still enclosed in the membrane of the egg, a large proliferation of cells is formed in front of it round the slightly wounded tissue."

The reproduction of the Cynipidæ is attended with some strange phenomena, which have not been understood till quite recently. It has been found that a true alternation of generations exists in many species of the family. This is of the kind defined by Balfour as heterogeny; that is, there is an alternation of sexual and parthenogenetic generations. In many cases the two generations of a species differ so greatly that they have been placed by systematists in different genera.

As observed by Adler, *Neuroterus lenticularis* produces, on the under surface of the leaves of the oak, galls which appear in July and fall to the ground in September or October. The larva is at this period very small, and the perfect insect does not come out till April or the beginning of May. Scarcely has it escaped from the gall



FIG. 634. — Galls of *Cynips quercus-spongifica* and *C. quercus-inana*.

in which it was developed, when it deposits its eggs upon the buds of the oak. Around these eggs are formed, upon the leaves and peduncles of the male flowers, galls differing from those which had nourished the *Neuroterus*. The insect which emerges from them is no *Neuroterus* at all, but has been classed in another genus under the name of *Spathogaster haccarum*. This, in its turn, will deposit eggs which will produce *Neuroteri*. The same alternation has been observed in three other species of *Neuroterus* corresponding to three distinct species of *Spathogaster*. "Not only do the two generations live in galls differing in form, color, and situation, and the insects exhibit among themselves differences of size, proportions, and structure, but what renders the contrast more striking is that the *Neuroterus* generation is only represented by females, whilst the *Spathogaster* generation presents individuals of both sexes."

Although alternation of generations occurs in many species of the Cynipidæ, it is believed that there are other species in which the parthenogenetic form exists alone, that is, the species reproduced continuously without any males appearing. There can be no doubt that these parthenogenetic species have descended from sexual forms. Still it is said that no case is now known of a sexual form existing alone. "All the sexual species are only known to us as a link in a cycle containing an organic genera-

tion." Mr. Adler has shown, however, that in *Rhodites roseæ*, the fly of the common rose gall, and in *Rhodites eglanteriæ* there is a manifestation of atavism, thus confirming the bands which exist between the sexual and organic states. "Although reproduction among them has become entirely parthenogenetic, yet at times males appear, although probably no copulation has taken place for a long period."



FIG. 635.—*Rhodites roseæ*, rose gall-fly.

There are several genera of gall-flies which, although they live in galls, do not produce them. These are known as guest gall-flies or inquilines. The adult insect lays her eggs within galls which have already been formed by other insects. In some instances at least, the

guest does not starve nor injure the owner of the gall.

In a third section of this family the insects are true parasites, living within the bodies of other insects. The habits of these species resemble those of the Chalcididæ.

The family CHALCIDIDÆ is an immense group composed almost entirely of parasitic species. Kirchner, in 1867, enumerated twenty-four hundred and seven European species; and although less than five hundred North American species have been described, an examination of the larger collections leads us to the conclusion that the North American fauna in this family is still richer. In general the species are small in size, the largest (*Leucospis* and *Smicra*) not exceeding the common honey-bee, while the smallest species (*Poropœa* and *Trichogramma*) are frequently not more than a quarter of a millimeter in length. In color they are nearly always black with strong metallic reflections; but many yellow species are known, and even red is often found in the markings of the larger species of the genera *Spilochalcis* and *Smicra*.



FIG. 636.—*Smicra marieæ*.

The species are all active and essentially diurnal in their habits. The body varies greatly in form, as shown in the accompanying figures of several species parasitic upon scale insects. The difference between the sexes is often very marked, and a striking example of this is seen in *Tomocera californica*, both sexes of which are figured. This species is parasitic upon *Lecanium oleæ*, the "black scale" of California, and the male might readily be taken for a species of a different genus without positive evidence to the contrary.

In general the head is large, becoming enormous in *Caratomus* and allied genera, and is carried at right angles to the body. The number of antennal joints varies from seven to thirteen, and there is the greatest possible diversity in the character of the flagellum. The eyes are large, and the ocelli are so placed as to form a triangle. In certain genera of the very abnormal group of fig-feeders, *Agonidae*, the ocelli are wanting, and in *Eupristina* both eyes and ocelli are absent. The thorax is highly developed, and the wings, although large and strong, are nearly destitute of veins. Many species lack the wings entirely. The ovipositor is usually hidden, though in the sub-family Toryminæ it is exerted and very long, and is used to penetrate galls. In the genus *Leucospis* the ovipositor is curved up over the dorsum of the abdomen to the thorax.

The female Chalcid lays her eggs either in or upon some other insect in one of its early stages of growth. The larvae usually feed internally, but occasionally they feed externally upon other larvae. All of the species of the sub-family Trichogramminæ, so far as we are aware, are parasitic upon the eggs of species of other groups, usually of Lepidoptera and Coleoptera. All other chalcids (with the exception of certain species of *Eupelmus* which are parasitic upon the eggs of Orthoptera and Heteroptera, and occasionally of Lepidoptera) oviposit upon larvae, and issue either from the larva or pupa. In the case of the internal feeders the larva transforms to a naked pupa within the body of its host, while the external feeders often spin a slight cocoon. With some of the Eulophinae, however, the host is entirely destroyed, and the larvae transform without covering upon the surface of the leaf. In this case, however, the pupal epidermis is very thick and tough, so much so as to obscure the form of the insect.

Not all of the Chalcididae are parasitic. The sub-family Eurytominae closely approaches the Cynipidae, not only in structure, but also in habits. The genus *Isosoma* of this sub-family contains several species which are phytophagous (*I. hordei*, *I. tritici*,



FIG. 637. — *Tomocera californica*, male and female.

and *I. vitis*), and one of them (*I. hordei*) causes an abnormal growth which is very like a gall. The species of the closely allied genus *Eurytoma* are bred in large numbers from Cynipid and Cecidomyid galls, and must be considered as inquilinous rather than as parasitic.

All of the orders of Hexapoda, with the exception of the Thysanura and Dermaptera, are subject to parasitic attack from members of this family. From the gigantic larva of *Telea polyphemus* which supports its hundreds of ravenous larvae of *Spilochalcis marie*, down to the minute pedunculate egg of *Heimerobius* with still more minute parasitic *Trichogramma*, hardly a species escapes. The amount of good they accomplish in the destruction of noxious insects is very great, and the sudden cessation in the work of some injurious horde, so often noticed by the agriculturist, is often in great measure due to their good offices.

The family PROCTOTRUPIDÆ is closely related to the preceding both in structure and in habits. The difficulty in separating certain members of the two groups has always been great, for want of some exact and decisive distinguishing character. Such a character has at last been observed by Thomson, and consists in the fact that in the Proctotrupidæ the pronotum always extends to the tegule, while in the Chalcididæ the borders of the mesoscutum always intervene. The Proctotrupidæ have not been

studied or collected with the same assiduity which has marked the study of the Chalcididae, and less than seven hundred European species have thus far been described, yet there is reason to believe that this group is nearly as rich in species as the family we have just considered.

In point of size of body, the Proctotrupidae are in general the smallest of the Hymenoptera. The largest species rarely exceed 4 mm. in length, while the sub-family Mymarinae contains the smallest insects known, *Alaptus excisus*, measuring only 0.17 mm. (between six and seven thousandths of an inch). *Mymar pulchellus* is about a fiftieth of an inch in length. In shape, the body is slender, and the color is almost invariably black or brown without metallic lustre. The head is frequently carried in the same plane with the body. The antennae are usually long and slender, in the males of some species exceeding the whole body in



FIG. 638. — *Mymar pulchellus*.

length. The wings are often wanting, and when present are entirely veinless, or they may approach (as in *Telenomus*) the venation of some of the Chalcididae, or (as in *Chelogyne*) some of the Braconidae.

In habits the Proctotrupidae are nearly all parasitic. Many species of the sub-family Scelioninae live in the eggs of other insects. *Telus* and *Telenomus* are often parasitic upon lepidopterous and heteropterous eggs, *Proscacantha* upon coleopterous, and *Beomara* upon the egg masses of orthoptera. Many species are internal parasites of other larvae, and many others are secondary parasites, that is, parasites upon species of the other closely related entomophagous families. Others again are external feeders; thus, the larvae of the curious genus *Gonatopus* are found fastened under the wings of leaf-hoppers. A few species are inquilines, but none, so far as we know, are plant feeders.



FIG. 639. — a, *Telus laviusculus*; b, *Telus* ovipositing in other eggs.

The family BRACONIDÆ is the Ichneumonides adsciti of authors. Under the popular name ichneumon-flies are classed the members of one of the most extensive groups of insects, a group including several thousand described species. By many this entire group is considered as constituting a single family, the Ichneumonidae. The species of this group may be recognized by the following character. The abdomen is attached to the thorax at its hinder extremity and between the bases of the posterior coxae. The wings are veined, the anterior pair always exhibiting perfect cells upon their disc. The ovipositor is straight and often exerted. The antennae are nearly always filiform or setaceous, and composed, except in a few small Braconids, of more than sixteen joints.

The larvae are soft, fleshy, cylindrical, footless grubs. They are parasites, usually infesting the larvae of other insects. Apparently no insect is safe from their attacks in however protected a place it may live. Even species which live within solid wood and those which inhabit water become their victims. They do not even spare the members of their own family. We thus find secondary and sometimes tertiary para-

sites. The female ichneumon-fly lays her eggs either in or upon the body of the insect on which her young are to feed. In the former case, the body wall of the victim is pierced by the ovipositor; in the latter case, the egg is fastened to the outer surface by a viscid substance. In some instances this viscid substance is drawn out in the form of a thread, and the egg attached to the distal end of it. These stalked eggs are usually attached to the head of the infested larva in such a position that the larva cannot rid itself of them. When the eggs hatch, the young ichneumons soon penetrate the body wall of their hosts. Here they feed upon the fatty portion of their victim, so that it continues to live until they become fully grown. Many caterpillars infested by these parasites live until after they have spun their cocoons and then perish. It is an interesting fact that, even in these cases where the ichneumons are protected by the cocoon of their host, each one spins for itself a cocoon before transforming to a pupa. Lepidopterous cocoons are often found which are packed full of the cocoons of ichneumons. These facts seem to indicate that these species of parasites have descended from forms whose habits were such that they needed cocoons, and that the cocoon-making habit has been retained when it is obviously of little or no use to the species.

In the case of caterpillars which die before spinning their cocoons, the ichneumon larvæ, when full grown, leave the body of the caterpillar and attach their cocoons to the outside of it or to some neighboring object. This emergence from the caterpillar frequently takes place before the host dies, and thus a feeble caterpillar may often be seen crawling about with the cocoons of its parasite attached to it. Although the majority of ichneumon-flies infest the larvæ of other insects, some are egg parasites, and a few infest pupæ. It should be borne in mind that each species of these parasites infests one or more particular species of insects. Thus, from a particular species of insect we may expect to obtain only certain species of parasites. The importance of this group of insects, from an economic standpoint, is very great. The undue increase of insects injurious to vegetation is prevented by these parasites, perhaps more than by any other agency.

The above generalizations refer to the entire group of ichneumon-flies, the Ichneumonidæ of certain authors. This group is now divided into two families. One is called the Braconidæ, and for the other the name of Ichneumonidæ is retained. The best character for separating these two families is by the nature of the venation of the front wings. In the Braconidæ there is only one recurrent vein, while in the Ichneumonidæ there are two. This is illustrated by Fig. 640. A and B represent the wings of *Agathis* and *Bracon*, two Braconid genera; and C and D the wings of *Ophion* and *Metopius*, two Ichneumonid genera. The letter *a* in each wing indicates the margino-discal vein, and *b* the recurrent veins. In the Braconidæ the abdomen is often composed of only three or four segments; whilst in the Ichneumonidæ it has always at least five segments.

As illustrating the Braconidæ, we will cite only three genera, *Bracon*, *Microgaster* and *Aphidius*. Fig. 641 is *Bracon pulpebrator*, greatly enlarged. Fig. 642 repre-

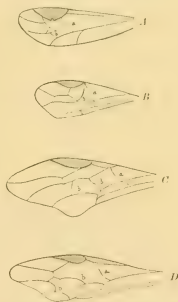


FIG. 640. — Wings of Braconidæ and Ichneumonidæ. A, *Agathis*. B, *Bracon*. C, *Ophion*. D, *Metopius*.

sents a caterpillar from which the full-grown larvæ of a *Microgaster* are emerging, and a greatly enlarged figure of an adult *Microgaster*.



FIG. 641. — *Bracon palpebrator*.

From each one there emerges in due time an *Aphidius*. The parasite, in emerging, cuts a very regular circular lid in the dorsal wall of the abdomen of its host. I have watched with much interest these little Braconids ovipositing in the bodies of plant lice. The female alights upon a leaf and runs about among the plant lice. When she has selected one in which to oviposit, she stands with her head towards it, and bending her abdomen under her thorax between her legs, she darts her ovipositor forward into the body of the aphid. The *Aphidii* do not construct cocoons, but undergo their metamorphoses within the dried skins of the plant lice.



FIG. 642. — *Microgaster nemorosum*, and a caterpillar covered with *Microgaster* larvæ.



FIG. 643. — *Ophion macrurum*.

about trees infested by *Sirex*, and the females are often found with their long ovipositors deeply sunken into the trunks of such trees in the act of laying their eggs in the bodies of the wood-boring larvæ.

The ICHNEUMONIDÆ proper includes the largest species of ichneumon-flies as well as many minute forms. The characters of this family and generalizations respecting the habits of its members have been given above in the discussion of the Braconidæ. We will now merely indicate a few of the more familiar examples of the family.

Our largest and in some respects most interesting species belong to the genus *Rhyssa*. The females of this genus are remarkable for the length of their ovipositors, which frequently measure three or four inches. These insects are parasitic upon wood-boring larvæ, and especially those of the genus *Sirex*. Both sexes may be seen flying

Probably the most common of our large ichneumon-flies are those of the genus *Ophion*. The species of this genus are honey yellow in color. At night they are frequently attracted by light. *Ophion macrurus* infests the American silkworm, *Tela polyphemus*. The female *Ophion* lays a single egg in the body of the caterpillar. The caterpillar lives until after it has become full grown and spun its cocoon. It then



FIG. 644.—a, *Exenterus marginatorius*; b, *Bassus albosignatus*.

perishes before changing to a pupa. The ichneumon larva leaves the body of its host and spins a dense cocoon of brownish silk within its cocoon. The shrivelled remains of the caterpillar occupies a small space between the two cocoons.

This same silkworm is infested by another ichneumon-fly, *Cryptus extrematis*. This is a much smaller species, and the female of it, in ovipositing, lays many eggs within a single caterpillar. The subsequent history of the species is similar to that of *Ophion*. Each *Cryptus* larva spins a cocoon within the cocoon of the silkworm. This results in the latter cocoon being packed full of the smaller cocoon. From a single *Polyphemus* cocoon I have bred thirty-five adult specimens of *Cryptus*.



FIG. 645.—*Cryptus extrematis*.

Two of the smaller European forms are represented in Fig. 644: *Exenterus marginatorius* ovipositing in a caterpillar, and *Bassus albosignatus* approaching a *Syrphus* larva. *Banchus fuscator* is another common European form.



FIG. 646.—*Banchus fuscator* and pupa.

The family EVANIIDÆ is a small group comprising insects of very peculiar structure. They are, however, sometimes classed as a sub-family of the Ichneumonidæ. They may be distinguished by the following characters: the antennæ are filiform or setaceous with not more than sixteen segments, usually with but thirteen or fourteen. The abdomen is jointed to the dorsum of the metathorax by a peduncle which sometimes arises close to the scutellum. The ovipositor is straight and often prominent. The fore wings are furnished with a distinct radial cell and from one to three cubital cells. The hind wings are almost without veins. The

species are parasitic. *Ectonia lævigata* was found by Packard to be parasitic upon the cockroach, *Periplaneta*. *Pelecinus polygervator* is a common species in this country. The members of this genus are remarkable for the great length of the abdomen in the females.

SUB-ORDER II. — ACULEATA.

In the classification of specimens the Aculeata can be distinguished from the Terebrantia by the form of the trochanters of the posterior legs; these consist of two segments each in the Terebrantia, and of a single segment in the Aculeata. This character is much more available for practical use than those which give the names to the sub-orders.

The Aculeata includes the ants, cuckoo-flies, digger-wasps, true wasps, and bees. The ants (Formicidæ) may be recognized by the lenticular shape of the first (and sometimes also the second) segment of the abdomen, and in the winged forms by the absence of tegulae at the base of the wings. The cuckoo-flies (Chrysididæ) have only three or four visible abdominal segments (very rarely there is a fifth in the males); the body is colored with bright metallic colors, and the wings are without any completely closed cubital cell. In the digger-wasps (fossorial hymenoptera) there is at least one closed cubital cell; the first discoidal cell is not greatly elongated, and is smaller than the median cell. The wings are not folded when at rest; tegulae are present, and the first segment of the posterior tarsi is cylindrical. The true-wasps (Vespidæ) agree with the digger-wasps in having at least one closed cubital cell, in the presence of tegulae, and in the cylindrical form of the first segment of the posterior tarsi, but differ in having the first discoidal cell much elongated and larger than the median cell, and in having the wings folded when at rest. The bees (Apidæ) are distinguished from all other Hymenoptera by the form of the first segment of the posterior tarsi, which is more or less enlarged, flattened, and clothed on the inside with hairs for the collection and carrying of pollen.



FIG. 647. — *Polyrhachis arborea*, worker major.

The family FORMICIDÆ or FORMICARLE includes the ants, easily recognized by the well-known form of the body. The only insects which are liable to be mistaken for ants are the white ants belonging to the Pseudoneuroptera, and the Mutillidæ, which are to be described a little later. But the ants are readily distinguished from these and other insects by the form of the abdomen. The first segment of the abdomen, and in one sub-family the second also, forms a lenticular scale or knot varying in form and serving as a peduncle to the abdomen as shown in our figures of *Polyrhachis* and *Eciton*.

The ants are social insects; that is, a large number of them live together in a common nest. Usually each species consists of three forms, male, female, and worker. In a single known genus (*Anergates*) there are only males and females. The workers are really females in which the reproductive organs are not fully developed, and which but rarely produce eggs. In many species there are two kinds of workers. One of these differs from the ordinary workers in having much larger heads and more powerful jaws. These are known as soldiers. "In the sauba ant of South America (*Erodoma cephalotes*) the complexity is carried still farther. Bates has shown that

there are in this species no less than five classes of individuals, namely: 1, males; 2, queens; 3, small ordinary workers; 4, large workers, with very large hairy heads; 5, large workers with large polished heads."

The habits of ants have been studied by many observers. The observations of Sir John Lubbock are, however, the most extended. He has kept in captivity a large number of species (about half of the British forms as well as a considerable number of foreign species), and during the last few years he has had from thirty to forty communities under observation in artificial nests, some of which have been under continuous observation for eight or ten years. The following generalizations respecting the family are drawn largely from his publications.

The eggs are white or yellowish and somewhat elongated. They are said to hatch in about fifteen days after being laid. Those observed by Lubbock have taken a month or six weeks. The larvæ, like those of bees and wasps, are small, white, legless grubs, somewhat conical in form, being narrow towards the head. They are carefully



FIG. 648. — *Ecodoma exphalotes*, sauba ant.

tended and fed, being carried about from chamber to chamber by the workers, probably in order to secure the most suitable amount of warmth and moisture. The larvæ are very often assorted in groups in the nest according to size, "so that they remind one of a school divided into five or six classes."

The length of life of the larvæ is known to vary in different species from one to several months. It varies also in the same species according to the season, development being more rapid in the summer months.

"When full grown the larvæ turn into pupæ, sometimes naked, sometimes covered with a silken cocoon, constituting the so-called 'ant eggs.' We do not yet understand why some larvæ spin cocoons, while others remain naked. As a general rule the species which have not a sting spin a cocoon, while those which have are naked. Latreille was the first to observe that in one species (*Formica fusca*) the larva sometimes spins a cocoon and sometimes remains naked." The ants generally remain from three to four weeks in the pupa state. The pupæ are unable to emerge from the cocoons without the assistance of the workers. "It is very pretty to see the older ants helping

them to extricate themselves, carefully unfolding their legs and smoothing out the wings with truly feminine tenderness and delicacy."

It has been supposed that the male ants live but a very short time in the adult state; that the workers exist only a few months; and that the average life of a queen is not more than twelve months. Lubbock is of the opinion that as a rule the males die almost immediately. At the same time some males of *Myrmica ruginoides*, which he isolated with their mates in August, 1876, lived until the following spring; one of them till May 17. He found, however, that the life of the queen and workers was much longer than had been supposed. At the time of his writing he had two queens which he had kept seven years, and which still seemed quite strong and well. He had also some workers which had been in his nest six years.

The three forms of ants may be distinguished as follows: The workers are wingless;



FIG. 649. — *Eciton samachristi*, worker minor.

their thorax is narrow, being more or less compressed; and the ocelli are wanting or are small. They constitute the greater number of the members of the colony, and are the ones most commonly seen. The males and females are always furnished with ocelli, and are both winged when they emerge from the pupa state. After pairing, which takes place in the air, the females shed their wings. Even then this sex may be readily distinguished from the wingless workers by the large size, by the different form of the thorax (it being wider, not compressed, and showing the basal part of the articulation of the wings), and by the presence of ocelli. The males are intermediate in size be-

tween the workers and females. They may be distinguished from the former by the presence of wings and ocelli, and from the females by the fact that the abdomen consists of seven segments in the males and of only six in the females. In a few cases (*Tomognathus* and *Anergates*) the males are wingless. The males, as a rule, are found in the nest during only a small part of the year, but the females are there continually, and frequently several females or queens can be found in the same nest.



FIG. 650. — *Ecodoma mexicana*, female.

As already stated, the workers are really females in which the reproductive organs are not fully developed. Frequently there are found among the workers of a colony certain individuals which are fertile, but the eggs laid by them always produce males. Hence, the presence of a queen is necessary for the perpetuation of the life of the colony. Lubbock believes that ants, like bees, have the power of developing a given egg into either a queen or a worker.

The nests of ants vary greatly in form. Many species simply excavate little tunnels in the earth. These tunnels may open beneath a stone or other object, being thus concealed from view; or they may have an unobstructed opening in the surface of the ground, surrounded by the small quantity of earth which has been brought up in excavating the tunnel. From these simple nests, made by a dozen workers, every gradation may be found to the large mounds from six to ten feet in diameter, covering a complicated system of tunnels and galleries, and extending many feet under ground, the result of the labors of thousands of workers. In these nests the galleries

are partly below and partly above the natural level of the ground. Although the majority of ants build their nests in the ground, many species cut passages in wood. These usually work in the trunks of trees which are more or less decayed, or in fallen timber. Occasionally the nests are constructed in the timber of buildings. The forms of nests indicated above are the more usual ones in this country. Many striking variations from these are known. The writer observed a nest near Prairie du Chien, Wis., which consisted of a pit, two feet in diameter and three feet deep, with nearly vertical sides. This pit was filled with small sticks of wood, which were piled to a height of eight inches above the natural level of the ground. Around this heap of sticks was placed the dirt which had been brought up in excavating the pit. The whole resembled an ordinary ant hill, except that the central part consisted only of sticks. These sticks were little twigs, petioles of compound leaves, and straws, varying from one inch to three inches in length. In the pit among these sticks there was almost no earth.

I have also a fragment of an ants' nest from Arizona, which appears to be made of a sort of paste which very closely resembles the substance used by certain white ants in constructing their nests.

"In warmer climates the variations are still more numerous. *Formica bispinosa*, of Cayenne, forms its nest of the cottony matter from the capsules of *Bombac*. Sykes has described a species of *Myrmica* which builds in trees and shrubs, the nest consisting of thin leaves of cow-dung, arranged like tiles on the roof of a house; the upper leaf, however, covering the whole. In some cases the nests are very extensive. Bates mentions that while he was at Para an attempt was made to destroy a nest of the samba ants by blowing into it the fumes of sulphur, and he saw the smoke issue from a great number of holes, some of them not less than seventy yards apart."

"A community of ants must not be confused with an ant hill in the ordinary sense. Very often, indeed, a community has only one dwelling, and in most species seldom more than three or four. Some, however, form numerous colonies. M. Forel even found a case in which one nest of *Formica exsecta* had no less than two hundred colonies, and occupied a circular space with a radius of nearly two hundred yards."

Ants construct roads. Sometimes these are merely beaten paths from which obstacles have been removed, and sometimes they are covered ways. On one occasion, when watching a stream of ants (*Formica rufa*) which was ascending and descending a tree, I noticed that the ants came from and returned to a hole in the ground at the base of the tree. On examination this hole proved to be the entrance to a road built beneath a firm layer of partially decayed leaves which covered the ground. This road varied from a half to an inch in width, and extended to an ant hill at least one hundred feet from the tree. I carefully uncovered the road for its entire length. The general course of it was direct, although there were numerous windings. That this road was a veritable tunnel, and not merely a way which had been covered by the falling of leaves, was shown by the fact that, after the layer of leaves had been removed, the road appeared as a ditch cut in the soil.

The food of ants consists of various sweet substances, as nectar, juices of fruit, and the excretions of certain insects. They also feed largely upon other insects. It is only necessary to watch an ant hill for a short time to be able to see ants bringing home insects for food. I have seen ants in cotton fields destroying great numbers of cotton worms. The importance of ants as destroyers of noxious insects is appreciated in Prussia, where the government has issued a decree against the destruction of

ants and their pupæ in the forests, on the ground of their keeping caterpillars in check; but, in certain parts of the northern United States, ants are looked upon as a nuisance, on account of the trouble caused by the great number of mounds which they make in meadows: and the little yellow ant (*Myrmica modesta*) which frequently installs itself in our dwellings is a serious pest both in the north and in the south.

The multiplication of communities of ants is a question which is not yet well understood. The queens and males which have been developed in a nest leave in a body, usually on some warm summer day. The pairing then takes place in the air. Frequently the males and queens, from many nests in one locality, take this marriage flight at the same time. Thus immense clouds of winged ants are often observed. After the pairing of the sexes the males soon perish. The females alight on the ground, and, after crawling about for a greater or less time, break off their wings. As ants pair only once, and as the subsequent duties of the queens can be performed without wings, this shedding of them is simply the discarding of useless appendages. Respecting the period from this point to the time when the new colony is firmly established, we have very little reliable data. As colonies of ants have been known to exist for a much longer period than we can reasonably suppose a queen to live, it is probable that some of the young queens, after pairing, join old colonies. Many of the young queens doubtless perish, falling prey to other insects and to birds. Others undoubtedly found new colonies. Lubbock has demonstrated that, in the case of at least one species (*Myrmica ruginodis*), the queen ant has the power of founding a new community. Experiments with other species indicate that this power is not common to all ants. It may be that in some species a queen associates herself with several workers, and they together begin a nest.

Although the number of ants in a community is often very great, reaching in some cases half a million, each ant will recognize every other member of the community as a friend, and will treat as a stranger any ant from another community. That the recognition of friends is not personal or individual is proven by the fact that, when a colony is separated into two parts for several months, the young ants which have been reared during this time in one part are recognized as friends when placed in the other part, although they have never been seen before. That the recognition is not due to the use of a pass-word, as has been supposed, is indicated by the fact that pupæ tended by the ants from a different nest are treated as friends in the nest from which they were taken, and as strangers, if put into the nest of their nurses. "for, if the recognition were effected by means of some signal or pass-word, then, as we can hardly suppose that the larvæ or pupæ would be sufficiently intelligent to appreciate, still less to remember it, the pupæ which were entrusted to ants from another nest would have the pass-word, if any, of that nest, and not of the one from which they had been taken." Dr. McCook came to the conclusion, from some of his experiments, that ants recognize one another by smell. It is hard to believe, however, that each community of ants has a separate and peculiar smell.

Much has been written upon the power of communication of ants: and it seems very well established that ants have some kind of language. How communication is effected is not known. It seems probable that it is, in part at least, by means of the antennæ. Every observer of these insects has seen ants meet and cross antennæ, and behave as if holding a conversation. Frequently the subsequent behavior of the ants seems to indicate that one has received information from the other.

Some of the most interesting phenomena connected with ants are the relations

existing between them and other insects, and in some cases between different species of ants. Very many species of insects live in ants' nests, the greater majority of which are beetles. Thus André gives a list of 587 species of insects which are habitually found in association with ants, of which number 542 are beetles. In the case of beetles, it is not clear just what is the relation existing between them and the ants; but, in case of certain other insects, the connection is easily seen. The most familiar example is the association of various species of plant-lice and bark-lice (Aphididae and Coccidae) with ants. In the summer time it is an easy matter to find lines of ants ascending and descending trees or other plants. If the ascending ants be watched, they will be found to go to colonies of plant-lice or bark-lice which are feeding upon the tree. From these insects the ants obtain a sweet secretion upon which they feed. The giving out of the sweet matter, or honey-dew as it is termed, can be easily seen in case of the plant lice. There is in many species a pair of tubes on the dorsal aspect of the abdomen, from which the honey-dew exudes. If a colony of plant lice which are attended by ants be watched for a few minutes, one will usually see ants soliciting the honey-dew by patting the aphids with their antennae, and the aphids will also be seen to respond by emitting from the honey tubes one or more drops of the bright, transparent liquid. In return for this honey-dew the ants exercise a protecting care over the plant lice, driving away predaceous insects which would destroy them, and caring for them in many other ways. Frequently ants keep their herds of plant lice in their nest. This is especially true of the common yellow ants which build their nests under stones, where the roots of plants can penetrate, from which the plant lice draw their nourishment. Thus the ants' nest serves also as a pasture for the herds of the ants. Other ants travel long distances to attend plant lice which are feeding upon herbs or trees remote from their nest. The long tunnel described in a previous paragraph was simply a road leading from the nest of the ants to a tree upon which their plant lice were feeding; and, as this was a tall forest tree, the ants, after reaching it, had to climb to a great height. Ants carry the plant lice about from one place to another, taking them from unold pasture to a new one. Sometimes they build a shed of mud over a colony of plant lice which are feeding on a plant in the open air; but perhaps the most wonderful thing in connection with the relations of ants and aphids is the fact, now well established, that not only do the ants care for the plant lice, but they also care for the eggs of the plant lice. And not merely for the eggs of those species which live in the nest of the ants, but also for species which feed on the leaves of plants in the open air. "The eggs are laid early in October on the food plant of the insect. They are of no direct use to the ants, yet they are not left where they are laid, exposed to the severity of the weather and to innumerable dangers, but brought into the nests by the ants, and tended by them with the utmost care, through the long winter months, until the following March, when the young ones are brought out and again placed on the young shoots of the daisy."

The plant lice (Aphididae) are the most common and abundant of the different insects which excrete honey dew and are attended by ants. Next in abundance are the bark lice (Coccidae). In this family only those species which are not furnished with a scale (Lecaninae and Coccinae) are thus attended. Certain other homopterous insects have the same relation to ants. I have often seen the two-spotted longhorn, *Enchospa binotata*, emit from the caudal end of its body a drop of clear fluid, which was eagerly eaten by attending ants, and which I believe to be honey-dew. The caterpillars of

some of our common small blue butterflies, *Lycena*, also are furnished with organs for excreting honey dew, and are attended by ants.

The relations which exist between different species of ants are in many cases very interesting. On this point I cannot resist quoting again from Lubbock. "It is hardly necessary to say that, as a general rule, each species lives by itself. There are, however, some interesting exceptions. The little *Stenommus westwoodii* is found exclusively in the nests of the much larger *Formica rufa*, and the allied *F. pratensis*. We do not know what the relations between the two species are. The *Stenommus*, however, follow the *Formicas* when they change their nests, running about among them, and between their legs, tapping them inquisitively with their antennæ, and even sometimes climbing on to their backs as if for a ride, while the large ants seem to take little notice of them. They almost seem to be the dogs or perhaps the cats of the ants. Another small species, *Solenopsis fugax*, which makes its chambers and galleries in the walls of the nests of larger species, is the bitter enemy of its host. The latter cannot get at them because they are too large to enter the galleries. The little *Solenopses*, therefore, are quite safe, and, as it appears, make incursions into the nurseries of the larger ant, and carry off the larvæ as food. It is as if we had small dwarfs, about eighteen inches to two feet long, harboring in the walls of our houses, and every now and then carrying off some of our children into their horrid dens.

"Most ants, indeed, will carry off the larvæ and pupæ of others if they get a chance; and this explains, or, at any rate, throws some light upon that most remarkable phenomenon, the existence of slavery among ants. If you place a number of larvæ and pupæ in front of a nest of the horse ant (*F. rufa*), for instance, they are soon carried off; and those which are not immediately required for food remain alive for some time, and are even fed by their captors.

"Both the horse ant (*Formica rufa*) and the slave ant (*Formica fusca*) are abundant species, and it must not unfrequently occur that the former, being pressed for food, attack the latter and carry off some of their larvæ and pupæ. Under these circumstances it no doubt occasionally happens that the pupæ come to maturity in the nests of the horse ant, and it is said that nests are sometimes, though rarely, found in which, with the legitimate owners, there are a few *F. fuscas*. With the horse ant this is, however, a very rare and exceptional phenomenon; but with an allied species, *F. sanguinea* [a species which occurs both in Europe and America], it has become an established habit. The *F. sanguineus* make periodical expeditions, attack neighboring nests, and carry off pupæ. When the latter come to maturity they find themselves in a nest consisting partly of *F. sanguineus*, partly of their own species, the result of previous expeditions. They adapt themselves to circumstances, assist in the ordinary household duties, and, having no young of their own species, feed and tend those of the *F. sanguineus*. But though the *F. sanguineus* are thus aided by their slaves, or, as they should rather, perhaps, be called, their auxiliaries, they have not themselves lost the instinct of working."

"*Polyergus rufescens* present a striking lesson of the degrading tendency of slavery, for these ants have become entirely dependent on their slaves. Even their bodily structure has undergone a change; the mandibles have lost their teeth, and have become mere nipples, — deadly weapons indeed, but useless except in war. They have lost the greater part of their instincts; their art, that is, the power of building; their domestic habits, for they show no care for their own young, all this being done by the slaves; their industry — they take no part in providing the daily supplies; if the

colony changes the situation of its nest, the masters are all carried by the slaves on their backs to the new one; nay, they have even lost the habit of feeding. Huber placed thirty of them, with some larvæ and pupæ and a supply of honey, in a box. 'At first,' he says, 'they appeared to pay some little attention to the larvæ; they carried them here and there, but presently replaced them. More than one-half of the Amazons died of hunger in less than two days. They had not even traced out a dwelling, and the few ants still in existence were languid and without strength. I commiserated their condition and gave them one of their black companions. This individual, unassisted, established order, formed a chamber of earth, gathered together the larvæ, extricated several young ants that were ready to quit the condition of pupæ, and preserved the life of the remaining Amazons.' This observation has been fully confirmed by other naturalists. However small the prison, however large the quantity of food, these stupid creatures will starve in the midst of plenty rather than feed themselves."

Since the publication of Dr. McCook's work on the honey ants (*Myrmecocystus molliger*) in 1882, this interesting species has attracted considerable attention. Its peculiarity is that one form of the worker has its abdomen distended to the size of a currant and entirely filled with grape sugar or "honey." The honey ants are found



FIG. 651. — *Myrmecocystus molliger*, honey ants with the abdomen swollen with honey.

in southwestern North America, usually at an elevation of from six thousand to seven thousand five hundred feet above the level of the sea, as far north as Manitou, Colorado, and south to the City of Mexico. The nest is a low, gravel-covered moundlet, averaging six inches in diameter and two or three inches in height. The honey bearers are found clinging to the roofs of chambers a few inches under ground, and seem to act simply as cells for the storing of the sweet substance which is collected by the active workers from the exudations of the gall of an undescribed cynipid, found upon a species of dwarf oak. In times of famine, and in seasons when the exudation is not forthcoming, the honey bearer, or "rotund," regurgitates the honey drop by drop, and it is transferred to the stomachs of the hungry individuals in waiting. In other respects the economy of the colony does not differ materially from that of other species. Dr. McCook arrives at the conclusion that "the worker majors for the most part, and sometimes the minors, are transformed by the gradual distention of the crop and expansion of the abdomen into the honey bearers, and that the latter do not compose a distinct caste. It is probable, however, that some of the majors have a special tendency to this change, by reason of some peculiar structure or form of the intestine or abdominal walls."

The agricultural ant of Texas (*Pogonomyrmex barbatus*) clears large spaces, often twelve feet in diameter, for its nests, cutting down all vegetation within this space.

and laying out broad roads leading from it, over which to carry the supply of seeds which it stores up for the winter in subterranean chambers. These nests often occur in cultivated fields, when considerable damage to crops results. The leaf-cutter ant (*Ecodoma ferens*), however, is a much greater pest to the Texas agriculturist, as it often entirely denudes a fruit-tree of foliage in a single night. Large bodies of workers ascend the tree and occupy themselves exclusively with the work of cutting the leaves, which fall to the ground and are carried off to the formicary by other workers stationed below.

J. II. COMSTOCK.

The family CHRYSIDÆ is a group of small extent, comprising less than five hundred described species, of which about one hundred and seventy-five inhabit Europe. The species are of medium size, brilliant colors, and are active and diurnal in habits. They are called "cuckoo-flies" by the English, and "*Goldwespen*" by the Germans. The colors are usually brilliantly metallic, and the abdomen is frequently tipped with red. The larger species reach a length of half an inch or more. The head is of moderate size, never exceeding the thorax in width. The antennæ are elbowed and thirteen-jointed. The abdomen is large and with but three, four, or (in the male of *Cleptes*) five visible segments, convex above and flat or concave below, so that it is readily turned under and applied to the ventral surface of the thorax when the insect rolls itself up into a ball for protection. The sheath of the ovipositor is tubular and telescopic, and its segments correspond to the missing segments of the abdomen. The venation of the fore wings closely resembles that of some Proctotrupids (*Aphelopus* and *Anteon*), and the hind wings are almost veinless.

In mode of life the Chrysidæ are either parasites or inquilines, and are usually bred from the nests of wild bees and wasps of the families Apidæ, Eumenidæ, Crabronidæ, Philanthidæ, Nyssonidæ, Bembicidæ, or Pompilidæ. Some species of *Cleptes*, however, are true parasites on the saw-fly genus *Nematus*. *Cleptes nitidula* has been bred from the imported currant-worm (*Nematus grossularia*) in Europe, and may be found in this country. It is well proven that while certain species devour the larvæ of their hosts, others simply feed upon the stores of food, leaving the original occupants to die of hunger. They are well known to their prospective hosts, and it is said by Walekenaer that the bees of the genus *Haliictus* will congregate together to drive away any individual of *Hedychrum lucidulum* which has stationed itself at the mouth of their burrows to wait for an opportunity to oviposit.

Certain species may be called secondary inquilines. For instance, *Trypoxylon* intrudes upon the domiciles of *Odynerus*, carrying its own store of food with it, and closing the entrance against the return of the female *Odynerus*. To this comes *Chrysis cyanea* and lays the egg from which hatches a larva which devours the stores of the *Trypoxylon*. The larva of the cuckoo-fly transforms without cocoon to a pupa, and in this state passes the winter.

The succeeding five families, Mutillidæ, Scoliidæ, Lapygidæ, Pompilidæ, and Sphegidæ, may conveniently be classed together under the head FOSSORIAL HYMENOPTERA, or, in common parlance, digger wasps, in contradistinction to the true wasps of the family Vespidæ. This term is a useful one, as it is often convenient to be able to speak of these families collectively. The families Mutillidæ and Scoliidæ are included under this heading, rather than separated under the name Heterogyna,

which is applied by certain authors who consider the group thus formed as of equal value with Fossorial, as applied to the remaining three families.

The fossorial Hymenoptera are, as the name implies, diggers. This habit is characteristic of the group, but is not distinctive, as certain of the true wasps dig similar nests. The members of this group are solitary in their habits. Their legs are fitted for walking and burrowing only, and are not adapted to the collection of pollen, nor is the body ever clothed with hair fitted for the transportation of pollen, although certain species are hairy. The wings lie flat when at rest. This character, as contradistinguished from the fold in the wings of the true wasps when at rest, furnishes a ready method of distinguishing a digger from a true wasp, while the absence of polleniferous organs offers an equally available distinction from the bees.

In the fossorial Hymenoptera, a single female, working alone, prepares a nest for her offspring. This is usually done by excavating a hole in the ground or in wood, and placing therein a store of food consisting of spiders or of other insects, most often larvæ. An egg is then laid with the store, and the hole is closed. When the larva leaves the egg it finds itself upon a supply of food sufficient to last it until it is fully grown. The transformations are all undergone within the burrow, and the adult insect emerges soon after reaching the perfect state.

As a rule, each species exhibits a preference for a particular kind of food. Thus, the nests of one species will be found filled almost exclusively with spiders, of another with saw-fly larvæ, of another with beetles, of still another with caterpillars, and so on. Sometimes these stored-up insects are killed outright, but more often they are stung in such a way as to paralyze all motion, thus preventing them from injuring the eggs and young larvæ, and at the same time keeping them fresh for an indefinite period.

In many cases the hole excavated for this nest reaches a considerable depth, and is divided into a series of compartments, in each of which is placed a store of food and an egg. Some species, instead of digging burrows, make cells of mud, carefully selecting the material from which the cells are composed. Each cell is provisioned and supplied with an egg, as just described.

Certain species, instead of constructing nests for themselves, search for burrows made by other species, or for natural tubes, such as the interior of straws, in which to store their supplies; while others, again, lay their eggs in the already provisioned nests of other species, thus becoming inquilineous in their habits. A very few members of this group may be said to be truly parasitic. The adult insects are active, fly in the hottest sunshine, and are often found frequenting flowers. The females are sometimes wingless, and all of this sex are armed with powerful stings.

The following artificial arrangement will be found useful in separating the families of this group. In the first four families the pronotum extends on the sides to the base of the wings. In the Sphegidae it does not. In the Mutillidae and Scelididae there is a contraction on the ventral surface of the abdomen at the union of the first and second abdominal segments. In the Lapygidae and Pompilidae the ventral aspect of the abdomen is uniformly convex. In the Mutillidae the intermediate coxæ are approximate and the females are uniformly wingless, while in the Scelididae the middle coxæ are widely separated and the females are nearly always winged. The Lapygidae and Pompilidae are readily distinguished by their relative length of leg. In the former the posterior tibiæ do not reach the caudal end of the abdomen, and in the latter they extend beyond this point.

The family MUTILIDÆ includes the strange insects commonly known as solitary ants, so called on account of their solitary habits and their strong general resemblance to the true ants. Structurally, however, they are much more closely related to the Scoliidæ than to the Formicidæ. From the latter family they may be readily distinguished by the total absence of the characteristic knot or knots upon the peduncle of the abdomen. As with other solitary Hymenoptera, there are but two forms, male and female. The females are always wingless, and the males, with but few exceptions, are winged. The females lack ocelli, and are furnished with a powerful sting. In habit the species are in the main diurnal, though the African species of *Dorylus* are said to be nocturnal. The females run with considerable rapidity, secreting themselves on the approach of danger, and the males often frequent flowers. *Mutilla occidentalis* digs deep holes in beaten paths and stores them with flies and other insects, while one of the European species is said to live parasitically in the nests of humble bees. The creaking noise made by these insects is supposed to arise from the action of the pronotum on the front edge of the mesonotum. A common species in Texas is known by the name of "the cow-killer ant," on account of a popular superstition that its sting is very dangerous to live-stock.

The family SCOLIDÆ is closely related to the preceding, both in structure and in habits. Both sexes, however, are winged, with rare exceptions, and the females as well as the males are furnished with ocelli. The legs are short and stout, and the antennæ are short and thick, and generally convoluted and serrate in the females. The body is sometimes very hairy. The species are frequently of large size, especially in the tropical regions, and abound in sunny, hot, and sandy places. While the majority of the species of this family undoubtedly have the normal fossorial habit; certain species are supposed to be parasitic. For instance, Passerini found the larva of *Scolia flavifrons* within the body of the lamellicorn beetle *Oryctes nasicornis*, and similarly Coquerel states, that *Scolia oryctophaga* lives on *Oryctes sinia* in Madagascar. Sumichrast supposes that the females of *Scolia azteca* lay their eggs in certain larvæ which abound in tan at Tehuacan. *Tiphia inornata* is a very commonly observed species in the eastern States. It makes perpendicular burrows in sandy soils, and the males are found frequently on flowers. *Elis quadrinotata* and *Elis plumipes* have been commonly observed on the cotton plant at the south, and are supposed to carry off the larvæ of the cotton worm (*Aletia xylinia*). *Myzine scsevincta* is a very commonly collected species south of New England. Both sexes frequent flowers, and, although possessing no polleniferous organs, undoubtedly have considerable influence in the cross-fertilization of certain plants. It is very abundantly found upon *Syringa*.

The SAPYGDÆ is a small family, comprising not more than a dozen European species. The body is generally smooth and slender and ornamented with yellow. The antennæ are long and more or less clavate, the head is long and the pronotum very broad. It is well proven that the typical genus *Sapyga* is inquilinous in the nests of wild bees, commonly of the genus *Osmia*. The cocoons of *Sapyga punctata* have been found in the cells of *Osmia helveticola*, and the female of the same species has been observed entering the cells of *Osmia bicornis* and *O. caryalescens*. On the other hand we have the old statement of St. Fargeau, to the effect that the females make burrows in the mortar of walls or in wood, in which they place their eggs and stores, adding in support of this hypothesis only that he had observed the common *S. punctata* carrying a larva. The eggs of the last-named species are 2.1 mm. long, elongate-oval in form, slightly thickened at one end.

The POMPILIDÆ is a larger and more important family than either of the two preceding. Its representatives are well known and feared, on account of their formidable sting. They are slender in form, usually black in color, occasionally variegated with red or orange, and with dusky, reddish, or black wings. The tropical species are often very large, and, in fact, among the species of the genus *Pepsis* are to be found the largest of known Hymenoptera. *Pepsis luros* of Cuba is over two inches long.



FIG. 652. — Wasps. a, *Pompilius antecoxus*, stinging a spider; b, *Agria punctata* and its cell; c, *Pompilus trivialis*; d, its larva feeding on a spider; e, *Procneus extragatus*.

The insects of this family have very long, slender legs. The abdomen is oval and attached to the thorax by a very short peduncle; the pronotum is quadrate, and the wings have two or three perfect submarginal cells.

The name "sand-wasps," which has been applied to these insects, is derived from their almost universal habit of digging burrows in sandy places, and provisioning them with stung insects. There are, however, exceptions to this rule. *Pompilius petiolatus* has been observed forming a nest of clay in the chinks of a wall, and the entire genus *Ceropales* seems to be parasitic or inquiline, laying its eggs in the nests of fossorial species. *Ceropales ruficollis* has been bred from the mud-nest of *Agynia*, a member of the same family, and the American *C. rufiventris* has been similarly bred from the cells of *Agynia bombycina*.

The typical genus *Pompilius* is one of large extent, and over five hundred species are known. The so-called "tarantula-killer" of Texas (*Pompilius formosus*) stores its burrow with the great southwestern spider, *Mygale hertzii*, erroneously known as a tarantula. Its burrow is five inches deep, and but one *Mygale* and one egg are deposited in each. Occasionally the spider succeeds in capturing the wasp, but this does not often happen. The wonderful effect of the sting is well shown by Dr. Linnaeus, who states that he has found spiders stored away, on which the egg of the *Pompilius* had failed to hatch, and that, after an evident



FIG. 653. — *Ceropales*.

lapse of several years, the spiders were still limber and showed no signs of decomposition. This species has but one annual generation, and the adults issue in June. They



FIG. 654. — *Pompilius formosus*, tarantula-killer.

feed by preference from the blossoms of *Asclepias quadrifolia*, which blooms in Texas throughout the summer. *Pompilius natalensis* is one of the most beautiful species of this genus. Its head and thorax are velvety black, antennae yellow, fore legs and tip of abdomen brilliant red, and wings gold-yellow. In Natal it is almost domestic, flying in and out of the houses, capturing the house-spiders, and making its nests before the door or under the veranda.

Agania and *Priocnemis* are allied genera. The females of the former build little barrel shaped cells of clay, which may

be found under the bark of trees, in the crevices of walls, and sometimes in sand burrows. *Agania bombycina* makes its cells under prostrate logs in South Illinois, while

the allied *A. subcorticalis* preferably selects a position under the loosened bark of standing trees. Species of the parasitic genera *Pteromalus* and *Mesostenus* have been bred from these cells by Walsh.

The family SPHEGIDÆ is a group of large extent and of considerable diversity of character. It includes the eight sub-families, Larrinæ, Spheginæ, Mellininae, Bembecinae, Nyssoninae, Philanthinae, Pemphredoninae, and Crabroninae, nearly all of which have been considered at one time or another as having family rank. As already stated, the Sphegidae are separated from the rest of the digger wasps by the pronotum, which does not extend to the base of the wings.

The sub-family Larrinæ is of small extent, and is composed of insects of small size, rather slender form, ovoid-conical abdomen, and with a single spine at the base of the middle tibiae. The mandibles are notched exteriorly near base, and the labrum is concealed. Although the European and North American species of *Larrada* and *Tachytes* are said to be burrowers in the ground, particularly in sandy soil, a Brazilian species of *Larrada* is said by Mr. H. W. Bates to form for itself cells composed apparently of the scrapings of the woolly texture of plants, resembling bits of sponge or German tinder, and attached to leaves. The anterior tarsi of this species differ decidedly from those of the burrowing species and indicate well the difference in habit. *Tachytes aurulentus* frequents the blossoms of *Asclepias*, and is often found with the pollen masses attached to the hairs of its tarsi. The tarsus figured by Packard in his



FIG. 655. — *Agania bombycina* and cell.

Guide, and which is referred to *Tachytes*, is stated by Patton to belong to *Sphex*. The American *Tachytes harpur* has been observed by the latter author carrying to her nest a female specimen of *Nyphidium brevipenne*, but beyond this no observations have been made upon the habits of American species of this genus.

In the sub-family Sphegina, the prothorax is narrowed in front, forming a sort of a neck, the basal segment of the abdomen is narrowed into a long petiole, and the mandibles are internally dentate. In habit the members of this sub-family differ decidedly, many species digging burrows in the soil, while others are "mud-daubers," plastering their earthen cells upon the walls of houses. *Amnophila* digs rather a deep burrow, with a chamber at its extremity. The female of *A. sabulosa* provisions her nests with caterpillars, often selecting large cut-worms. Usually four or five caterpillars are placed in a single nest, and each time that one is deposited the female carefully stops up the entrance with a few pebbles until her return. If the weather is favorable the nest is completed and filled in a few hours, and she then proceeds to construct a fresh burrow. The same species is said to occasionally attack spiders, and *A. viatica* invariably collects these latter insects. *Amnophila pictipennis* provisions its nests with cut-worms, in South Illinois.

The genus *Ampulex* is said to be parasitic in its habits, *A. sibirica* ovipositing in the bodies of cockroaches at Sierra Leone. The genus *Sphex* is fossorial, although there seems to be no hesitation on the part of certain species in appropriating the burrows of other insects. *Sphex tibialis* has been reared from cocoons occupying a tunnel of *Xylocopa virginica*. *Sphex ichneumonea* digs rapidly into hard ground, using both jaws and fore legs in the process, and a single female completes two or three burrows five inches deep in the course of an afternoon. She preferably provisions her cells with *Orchelimum* and allied forms. An exception to the burrowing habit is seen in the case of *Sphex laniarii*, which makes its cells of a cottony substance and places them in the roll of a large, curved leaf.

The mud-daubers of this sub-family belong principally to the genus *Pelopaeus*, and are dark, slender insects, with long, petiolated abdomens. Their cells of clay are plastered in all sorts of secluded places, on the under side of fence rails, in barns and out-houses, and even the inner walls of dwelling-houses are frequently disfigured by them. The cells are provisioned with spiders, flies and caterpillars. The finding of numerous puparia of a *Sarcophaga* in the cells of *Pelopaeus flavipes* in Texas seems to point to the fact that the female flesh fly takes advantage of the food stored by the dauber as admirably adapted to the uses of her own larvæ. The ichneumonid *Cryptus janceus*, lays its egg in the larva of *Pelopaeus*, and its larva subsequently, after destroying the larva of the mud-dauber, spins for itself a thin, white cocoon within the cell. The beetle *Trogoderma ornatum* is also frequently found feeding on the dried remains of the spiders after the adult *Pelopaeus* has issued from the cell. *Pelopaeus caruleus* is frequently found upon the cotton plant in the Southern States, and has been observed to capture the half-grown cotton worms.

The sub-family Mellinina has been erected for the interesting genus *Mellinus*. The head is large, the legs slender and slightly spinose, and the abdomen lanceolate, with a long petiole. The anterior wings have one marginal and four submarginal cells. The habits of the typical species, *Mellinus arvensis*, are briefly as follows: The female digs a burrow in sandy soil, enlarging the extremity into a chamber, and proceeds to store it with various dipterous insects. A favorite hunting-ground is a bit of cow dung, on which sometimes several females will settle to await their prey. As the fly

is quicker of flight than the *Mellinus*, it is caught by slow approach or by stratagem. The wasp will frequently run slowly past her intended victim in an unconcerned manner until the latter is off its guard, when it is suddenly seized from behind and carried away. A number of flies are thus caught and stowed away in a single burrow. A single larva found feeding by Frederick Smith became full-fed in ten days, devouring in that time six flies. The larva spins a tough, brown cocoon and remains within it through the winter, transforming to pupa on the approach of the ensuing summer.

The Bembecinae is another small sub-family, represented in Europe by *Bembez*, and in this country by this genus and *Monedula*. The body is large and rather elongate; the head is large, and the legs are rather short; the labrum is long, triangular, and exserted. The habits are similar to those of *Mellinus*. The female of *Bembez rostrata* burrows in the sand, excavating with great rapidity and throwing the sand



FIG. 656. — European wasps. *a, b, Mellinus arvensis*; *c, e, Crata patellus*; *d, Trypoxylon fuscus*; *f, g, Glyceris arenaria*; *h, Crossocerus scutellus*; *i, e, elongatulus*; *k, Bembez rostrata*; *l, Orygates uniglutinis*; *m, Philanthus triangulum*; *n, Mellinus sabulosus*.

out with its fore legs. Its stores consist ordinarily of dipterous insects, which it captures, unlike *Mellinus*, on the wing. This species is subject to parasitic attack from two dipterous insects, *Panopea carnea* and *Toxophora fasciata*. The American species, *Bembez fasciata*, is common on the sea beaches at the north. *Monedula* is slenderer and more highly colored than *Bembez*. *M. carolina* is common in the cotton fields of Alabama and Georgia.

With the sub-family Nyssoninae, the mouth parts resume a more normal form, the head is long, the antennae somewhat clubbed, the jaws are not emarginate beneath, and the legs are rather spiny. The abdomen is either sessile or petiolated. This is a larger sub-family than the preceding, and does not differ markedly in habits. The large species of the genus *Sphecius*, *S. grandis* or *S. speciosus*, is very noticeable, not only from its size, but also from the fact that it almost invariably provisions its nests with the large harvest fly, *Cicada marginata*. The habits of *Sphecius speciosus* have been carefully observed by Mr. A. S. Fuller, who states that he has

never known it to capture other food for its young than this cicada. Its burrow is dug in the light, dry soil of unfrequented paths. It is two feet or more in depth, extending obliquely downwards, and turning upwards at the end, and is three fourths of an inch in diameter. The earth from the burrow is heaped up near the entrance. In carrying its prey to the nest, the wasp ingeniously takes advantage of the wind, dragging the cicada up some tall tree and sailing off before a favoring breeze. A single cicada is sufficient provision for a single nest, and the great labor of excavation is done again and again before the supply of eggs of a single female becomes exhausted. The genus *Gorytes* is remarkable in that it mimics one of the true wasps, *Odynerus*. One of the European species of this genus carries off the larvæ of *Tettigonia*, one of the leaf-hoppers. The species of the typical genus, *Nyssus*, have the habit, rare among the wasps, of feigning death and dropping to the ground when alarmed.



FIG. 657. — *Sphecius speciosus*.

In the sub-family Philanthine the head is wider than the thorax, the intermediate tibiæ are armed with a single spur at tip, and the anterior tarsi are strongly ciliated. The males are peculiar in having a fringe of hairs resembling a moustache on the apical margin of the lateral lobes of the clypeus. The habits in this group are quite uniform and resemble those of other burrowers. The species are small, and their tortuous excavations seldom exceed a depth of five inches. The East Indian and South American species, however, are exceptions, and some of the species of



FIG. 658. — *Philanthus ventralis*.

Cerceris from tropical regions reach a length of one inch. *Philanthus triangulum* stores its nest with the common honey bee, *Apis mellifica*, and also with wild bees of the genera *Andrena* and *Halictus*. The genus *Cerceris* contains some of the most beautiful species among the fossorial Hymenoptera, and exhibits great diversity in the insects upon which its species prey. *Cerceris arenaria* stores up beetles of the family Curculionidæ, *Strophosomus*, *Balaninus* and *Otiorynchus*

having been collected in its burrows. The bees of the genus *Halictus* are favorite food for several species of this genus. A single female of *Cerceris hyposticta* will often place as many as fifteen beetles of the genus *Buprestis* in a single excavation.

With the sub-family Pemphredoninæ the fore wing has two complete submarginal cells. The species are of small size, with large head and ovate-lanceolate abdomen, mounted on a slightly curved petiole. *Pemphredon lugubris* is an extremely common English species. The female burrows into decaying posts, rails, and logs, and provisions her cells with different species of aphides. She will settle on a rose leaf, for example, and scrape a number of the plant lice together into a ball, flying off with it, carrying it with her front legs just under her head. *Pemphredon minutus*, however, makes its burrow in sand, while at least one species of the allied genus *Stigmus* (*S. troglodytes*, by some authors placed in the genus *Celia*) makes its cells in the hollow straws of thatched roofs, provisioning them with masses of the larvæ of *Thrips*.

The sub-family Crabroninæ is a large and interesting group, exhibiting considerable diversity of habit and form. The head is frequently very large. The abdomen is oval or elliptical, sometimes clavate and sometimes petiolated. The eyes are ovate and sometimes reniform. The fore wings have but a single submarginal cell, and the

middle tibiae have a single spine. The larva is short and stout, and usually spins a dense brown cocoon. In habits, the group contains sand diggers, hard clay diggers, wood borers, species which excavate the pith of twigs, and species which adapt the old nests of many species of wasps. The genus *Trypoxylon* is particularly noticeable from its habit of adapting the old nests of other species to its own purposes. *Trypoxylon albitarse* is found abundantly in old cells of *Pelopaeus* in the western states, reprovisioning them with spiders. The South American *T. fugax* fills with clay the cells of a nest of *Polistes*, and the European *T. figulus* enlarges the burrows of wood-boring species. Any convenient tubular hole will be used by these insects, which thus make use of the cavities of straws, and of rose twigs from which the pith has been excavated by some *Crabro* or *Rhopalum*. The genus *Rhopalum* bores extensively in pithy stems. *R. pedicellatum* has been bred from the stems of rose, *Corcorus*, *Japonica*, and *Spiraea* in New York. The species of the genus *Crabro* are, in the main, wood-borers. *C. singularis* and *C. scemaculatus* are both American species which have this habit. *Crabro patellatus* of Europe, however, burrows in the sand and provisions its nest with Diptera. *Crabro tibialis* bores, like *Rhopalum*, into the pith of brambles and roses, and its nests are destroyed by the parasitic chrysid, *Hedychrum ardens*. The genus *Oxybelus* is composed of small, dark, active insects, usually with white-spotted abdomens. The female captures her prey, which consists of dipterous insects, in much the same way as does *Mellinus*. Alighting upon a sunny, grassy spot, she moves slowly around until the flies have become accustomed to her presence, when, with a sudden spring, she seizes a victim and bears it away in triumph.

The family VESPIDÆ includes the insects known as the "true wasps" in contradistinction to "sand-wasps," "wood-wasps," and other similar terms applied to the fossorial Hymenoptera. The true wasps may be distinguished from other Hymenoptera by the longitudinal folding of the wings when at rest. The antennæ are elbowed, and consist of twelve joints in the female and thirteen in the male. The labium is quadrilobed, or sometimes only bifid, each of the divisions being glandular at tip. The eyes are lunate. The abdomen is sometimes sessile and sometimes petiolate, and is composed of seven segments in the male and six in the female. The female is furnished with a retractile sting. The legs are slender, and are not hairy. The wings always present two recurrent nervures, and three or four sub-marginal cells. Both sexes are always winged. The body is either naked or slightly clothed with hairs. It is usually black in color, usually more or less spotted with some shade of yellow.

The true wasps vary greatly in habit. Some species are parasitic; others are solitary, living by rapine; while the higher forms are social. These three peculiarities of habit are correlated with structural peculiarities, so that the division of the family into three groups characterized by habits corresponds to the natural division into three sub-families based upon structure. These three sub-families are the Masarinae, or parasitic wasps, the Eumeninae, or solitary wasps, and the Vespinae or social wasps.

In the sub-family Masarinae the fore wings have only three submarginal cells, two of which are closed, the eyes are but slightly notched, and the wings are indistinctly folded. These insects are mostly tropical, but four or five being known in South Europe. In America the group is represented only by the genus *Masaris*, and the species all come from the extreme west.

The sub-family Eumeninae is most readily separated from the Vespine by the tarsal characters. In this group the claws are armed with a tooth, while in the Vespine they are simple. With the solitary wasps there are but two forms, male and female, each female performing the dual duties of queen and worker, building and provisioning her nest alone. The members of this sub-family exhibit considerable diversity in the manner in which they build their nests. Some make them of mud in the chinks of walls or other convenient holes. Some fasten their mud nests to the inner surface of walls or roofs of outbuildings, while others fasten similar nests to shrubs growing in the open air. Many species excavate tunnels in wood, availing themselves of the easily excavated pith of certain plants, while others bore into solid wood. Certain species again tunnel into the ground and into sandy banks. The nests are provisioned in a manner similar to that employed by the digger wasps.

The most important genus in this group is *Odynerus*. With the insects of this genus the abdomen is sessile or subsessile, and the shape of the body, and oftentimes the coloration, resemble those of the social wasps commonly known as "hornets" or "yellow-jackets." While some of the species of *Odynerus* are true wood and sand burrowers, others again will construct their cells in any convenient cavity. The cells of *O. albophaeratus* have been found in the deserted gall of *Diplolepis confusus*, arranged around one side of the gall, with their holes pointing towards the centre, *O. quadratus* has been known to make use of hollow reeds, of the accidental folds in a sheet of paper, and even of the barrels of a double-barrelled pistol which hung against the posts of a garden arbour. A specimen of *Odynerus flavipes* is said to have made its cell in the hole of an old cotton-spool. These insects store up a variety of species, seeming to prefer small lepidopterous larvæ.



FIG. 659. — *Odynerus flavipes* and cell in a spool.

Several species of the Ichneumonid genus *Cryptus* have been bred from *Odynerus* cells in Europe, and *Cryptus junceus* has been bred from the cells of *Odynerus birchinianus* in New Jersey.

The typical genus *Eumenes* may be recognized by the very long pedicel of the abdomen. This is formed by the first abdominal segment, and is either linear or sub-campanulate, and about as long as the thorax. The remainder of the abdomen is pyriform. The most common North American species is *Eumenes fraternus*. This species makes globular mud cells, very regular in form, and each furnished with a short neck, and attaches them to plants. In the eastern states the larvæ of the spring canker-worm (*Anisophteryx vernata*) is frequently found stored up in the cells of this species. The larva of the wasp occupies about a month in its development, and the adult insect issues through a hole which it breaks in the side of the cell.

With the Vespine or social wasps, there are, as with other social Hymenoptera, three forms, males, females or queens, and workers. The habits of these insects rival in interest those of the hive-bee, of which so much has been written. It is, however, much more difficult to study these insects than either the hive-bee or ants. As most of the species are very irritable, and possessed of quite venomous stings, it requires considerable tact and courage to investigate their habits closely.

The size of the communities of social wasps varies, at the season when they are

largest, and according to the species, from a few individuals to several thousands. These communities, unlike those of the hive-bee or of ants, have only a temporary existence. On the approach of winter the males and workers perish, and the fertile females crawl into such protected situations as crevices in walls or under the bark of trees, and there pass the winter in a dormant state. In the following spring each surviving female founds a new colony. At first she performs the duties of both queen and worker. A small nest is made, eggs are laid in it, and when the larvæ hatch, they are fed and cared for by the queen until they reach maturity. This first brood is composed entirely of workers. They relieve the queen of the duties which pertain to this caste, and from this time forth her only duty is to lay eggs. It is stated, however, by some authors, that she continues to assist in the care of the young, though not in the construction of the domicile.

The nests of the social wasps are composed of a papery substance made from wood. The wasps collect, with their mandibles, the semi-loosened fibres from the surface of

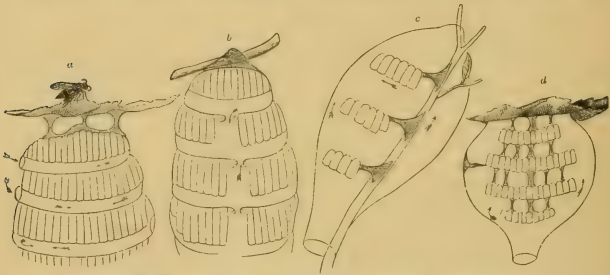


FIG. 660. — Diagrams of wasp nests. *a*, *Polybia scutella*; *b*, *P. rejecta*; *c*, *Chartergus apicalis*; *d*, *Polybia ampullaria*.

weather-beaten wood, which, by mastication and mixing with a buccal fluid, is made into pulp, easily moulded, and drying on exposure to air. The sides of unpainted buildings and of fence boards afford the chief supply in inhabited portions of the country. If a wasp's nest be closely examined, the paper will be found to be streaked with various shades of gray and brown, each little streak or blotch indicating the amount of material brought at once by a single wasp.

The essential part of a wasp's nest consists of a comb formed of hexagonal cells similar in form to the cells of a honeycomb. It differs, however, in several important respects from that of the hive-bee. The material from which it is composed is paper instead of wax. The comb consists of a single layer of cells instead of two, and the cells are usually vertical instead of horizontal. In some species the nest consists merely of a single comb with one or more stems holding it in place. In others the comb is enclosed in a spherical envelope with a small opening at the bottom. In the more complicated nests there is a series of combs placed one below the other, and the whole is enclosed in a spherical case made of many thicknesses of paper. The nests are enlarged by adding cells to the edges of the combs, and room is made for these new



Polybia palmatorum, palm wasp.

cells by removing the inner layers of the envelope, the portion removed being remasticated and added to the outside. The nests are suspended from the branches of shrubs and trees, or from fences and roofs. Certain species build their nests in holes in the ground.

In each cell of the comb an egg is laid. Owing to the position of the comb, when the larva hatches, it is suspended head downwards in its cell. This position they retain while young by means of a glutinous secretion, and later by the enlarged cephalic portion of the body, which completely fills the open part of the cell. The larvae receive constant attention from the females and workers, and are fed with nectar, the juices of fruits and of animals, and with more solid food chewed fine by the adults before feeding. On reaching full growth the larva spins a silken cocoon, the lower end of which serves as a cap to the cell, and transforms to a pupa. After the adult has issued, the cell is cleaned out and used again, as the whole period from the lay-

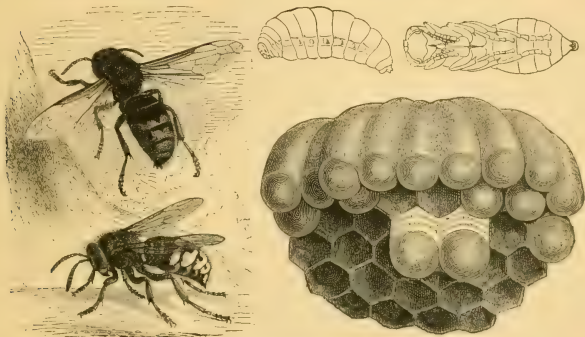


FIG. 661. — Larva, pupa, comb, and adult of *Vespa crabo*, hornet.

ing of the egg to the emerging of the adult is about one month at the north, so that the comb made early in the season serves for several successive broods. The males and queens are not developed until towards autumn. At this time larger cells are made for the reception of the eggs which are to produce the sexual forms.

Although the social wasps feed upon nectar, honeydew, and the juices of fruits, they are also carnivorous, destroying large numbers of other insects.

Our common species of social wasps represent the two genera *Polistes* and *Vespa*. To the genus *Polistes* belong the common long-bodied black wasps with folded wings and sub-pedunculate abdomens. They frequently enter dwellings in the autumn, seeking places for hibernation. The nest of *Polistes* consists of a single comb without envelope, and may be found in almost any country barn. They are also attached to bushes and to the lower surfaces of stones which are slightly raised from the ground. In this country these nests are almost invariably horizontal, but European writers figure the nests with vertical combs.

To the genus *Vespa* belong the shorter bodied wasps with folded wings, which are commonly known as "hornets" or yellow-jackets." These build nests consisting of a series of combs arranged one below another, and all enclosed by a spherical or egg-shaped envelope. The "white-faced hornet" (*Vespa maculata*) is our largest species. It is the American representative of the European *Vespa crabo* which has been introduced into this country.



FIG. 662. — *Vespa maculata*, white-faced hornet.

In the tropics the nests of *Vespa* often attain an immense size. The nest of a Ceylonese species reaches a length of six feet. A common South American form is made of such thick and firm paper that it resembles pasteboard. The outer layer is so fine in texture that it can be readily written upon with ink.

No parasites in the nests of wasps have been discovered as yet in this country, but in Europe a number of such species have been found. Two species of Ichneumonidæ, one of which is *Anomalton vesparum*, infest the larvæ. The larva of *Volucella* and *Anthomyia incana* destroy the larvæ in their cells, while the adult wasps are infested by *Rhipiphorus paradoxeus*, a beetle allied to *Stylops*.

The succeeding two families, ANDRENIDÆ and APIDÆ, have been grouped together under the sub-sectional or tribal name of MELLIFERA, or Honey Gatherers. As distinguished from the fossorial Hymenoptera, which we have just considered, this group may be characterized as follows: In the solitary species there are but two sexes, male and female; but in the social ones another is added in the shape of a neuter, abortive female, or worker. The females and workers, except in the hive and parasitic bees, are furnished with apparatus for carrying pollen, and are armed with a sting. The antennæ of the females and workers are twelve, and of the males thirteen-jointed. Nearly all in the larva state feed upon pollen or honey stored up by the adults, while some are parasitical, devouring the food stored up by other species.

The family ANDRENIDÆ includes the so-called "solitary bees." In this family the mentum is elongate, and the labium at its extremity is either spear-shaped or cordate. From this reason the group has been divided by certain authors into the Acutilingues and Obtusilingues. The labium and terminal maxillary lobes do not form an elongated proboscis. The trochanters and femora of the hind legs in the females are generally polleniferous. These insects are all solitary, and each species consists of but the two sexes. The females collect pollen, which they make into a paste for their cells. Nearly all the species burrow into the ground, forming their cells in either a straight burrow, or one which has branches with a common mouth. Certain species, however, use interstices in walls and bramble canes in which to make their cells.

The two genera, *Colletes* and *Prosopis* form the group known as Obtusilingues. The species of the genus *Colletes* usually burrow into the ground to a depth of from eight to ten inches, forming a simple burrow in which are placed six or eight cells formed of a thin, transparent membranous substance. One species, however, has been found making its cells in the chinks of a stone wall which had previously been filled in with earth or soft mortar. *Prosopis* has been considered parasitic, but the observations of Frederick Smith have proved the contrary. Its cells are commonly found in the hollows of bramble sticks, and an instance is recorded in which a hollow piece of flint stone was used for this purpose. A species of *Stylops* infests this genus.

Sphecodes, the first genus of the Acutilingues, has also been considered as parasitic upon bees of the genus *Haliectus*, but Smith has observed the females in the act of burrowing. They burrow in the same situations as the *Haliecti*, the two forming, as it were, mixed colonies, but each individual has a distinct burrow. The abovementioned author was firmly of the opinion that there are no parasitic or inquilinous species among the Andrenidae. The species of *Sphecodes* are smooth and wasp-like in appearance, and derive their generic name from their resemblance, both in form and habits, to the wasps of the genus *Sphex*.

The species of the genus *Haliectus* are very numerous, and are among the smallest of the bees. The species are often metallic in color. They dig branched cells to a depth of from six to ten inches, and are semi-gregarious in habit, a great many of the burrows often being found clustered together. This genus, together with *Sphecodes*, differs from all other solitary bees in the fact that the impregnated females hibernate, as with the Vespidae, and as with *Bombus*, among the social bees. The males and females appear in the autumn, the former antedating the latter in issuing. The females are impregnated and hibernate, the males dying. The ensuing spring the surviving females dig their burrows, make and provision their cells and oviposit. The common American *Haliectus parallelus* is stated by Emerton to be double-brooded. The egg of this species is long, slender, and much curved, obtuse at one end and much smaller at the other. The larva is also comparatively long and slender, and is large behind, tapering towards the head. Its body is somewhat tuberculated, enabling it to move about in its cell. The head of the pupa is furnished with six distinct, conical tubercles, two larger, between two of the ocelli, and four smaller, just in front of the ocelli. *Haliectus* is also subject to the attacks of *Stylops*.

The typical genus *Andrena* is of large extent, comprising nearly two hundred European species. In habit the bees of this genus closely resemble *Haliectus*, burrowing in light soil to a depth of from five to twelve inches, and preferably choosing a southern aspect. With the common *Andrena vicina* the burrow is perpendicular, with short side passages obliquely downwards. The sides of the walls are rough, but are glazed with a mucous-like secretion. The deepest cells are provisioned last. In Massachusetts the burrows are dug in May, provisioned by the last of this month, and the larvæ reach full growth by the last of July, transforming to pupæ early in August, and issuing as adults before the first of September. The larva differs from that of *Haliectus* in its stouter and less curved form, and in the less convex segments of its body. The bees of this genus are among the earliest insects seen in the spring, flying about in the sunshine and frequenting the willow catkins and other early flowers.

The insects of the family ANDRÆ are characterized by the long labium and mentum which, with the maxillæ, form an elongate proboscis, which may be folded



FIG. 463. Nest of *Andrena vicina*.

beneath the head and breast when not in use. They may be divided, according to their economy, into social bees, solitary bees, and parasitic bees. There is not, however, with this family, as with the Vespidae, a ready separation into structural groups corresponding with the three classes founded upon economy. The ordinarily accepted classification throws the species into five sub-families. From the latest catalogue it is seen that over seven hundred North American species of this family have been described, showing our bee fauna to be richer than that of Europe.

The sub-family Andrenoine consists of species closely allied to *Andrena*. In this group the labium is shorter than the mentum. The maxillary palpi are six-jointed. The females have no pollen-brush on the under side of the abdomen, but are furnished with one on either side of the metathorax, and the legs also have such brushes. In habits, also, these insects much resemble *Andrena*, excavating burrows and storing up pollen and honey in a similar manner. *Panurgus banksianus* forms large colonies in retired sandy places in England, burrowing to a depth of six inches, and making its appearance in July. All of the North American species are western.

The species of the sub-family Cueline form a well-marked group of naked, sometimes wasp-like, parasitic bees. They are destitute of polleniferous brushes and plates, and from their structure were supposed to beinquilines before their habits were definitely ascertained. *Nomada* is a genus of large extent, and its species lay their eggs in the cells of *Andrena* and *Halictus* as well as of some of the higher bees. They differ greatly in appearance from their hosts, yet seem to be on perfectly good terms with them, visiting flowers in their company and entering their burrows as unconcernedly as though they were the result of their own labors. Conjecture has been rife as to whether the egg of *Nomada* is deposited only in those pollen masses not already supplied by its host; or whether, the opposite being the case, the larva of the host is starved to death for the want of the food eaten by the earlier hatching *Nomada* larva; but the observations of Emerton seem to show that the food supply is sufficient for both larvæ, which live harmoniously together in the same cell, and issue at about the same time. The widespread *Nomada imbricata* is found in the nests of both *Andrena vicina* and *Halictus parallelus*. The larva is smooth, round, tapering towards each end, and has a small head. The pupa has three conspicuous spines on the upper and posterior edge of the orbit, which seem to aid in locomotion. The bees of this genus are often captured with masses of clay attached to their posterior tibiæ, with which, it is surmised, they close the cell of their host after ovipositing. With the other genera the habits are the same. *Celiocys* is parasitic in the cells of *Megachile* and *Saropoda*, *Epeolus* lives similarly on *Colletes*, *Melecta* on *Anthophora*, and *Stelis* on *Osmia*.

The sub-family Dasygastrina contains many insects of interest. They derive their name from the very large pollen brush which covers the ventral aspect of the abdomen. Pollen plates, however, are lacking. The labium is large and oblong, the mandibles are particularly strong, the maxillary palpi are but slightly developed, and the labial palpi are very long. The majority of the species bore in wood, and make their cells of moist earth or of bits of leaves cut by the mandibles to a proper form.

The species of the genus *Osmia* are called "mason bees," from the material of which their cells are composed. The greatest possible diversity is seen in the situations in which these are placed, and the bees show a high order of intelligence in the manner in which they adapt themselves to circumstances. Frederick Smith says: "If I were asked which genus of bees would afford the most abundant materials for an

essay on the diversity of instinct, I would without hesitation point out the genus *Osmia*." Certain species excavate the pith of brambles, alternately widening and contracting the burrow to correspond with the proposed cells and the intervals between them. Others bore into hard wood. Others use the hollows of reeds and straws. Others again plaster their cells thickly over the under-side of some flat stone which is slightly raised from the ground. Two European species utilize the empty shells of several species of *Helix*, compactly filling each shell with their cells, which are placed in different relative positions according to the exigencies of the case, and carefully closing the entrance with pellets of clay, sticks, and pebbles. *Osmia similima* arranges its cells in the interior of the large, deserted gall of *Diplolepis confluentus*. The cells of *Osmia leucomelana* are found in comparatively unprotected situations at the roots of grass. These bees are of comparatively small size, and are usually of



FIG. 661. — *Megachile centuncularis*, leaf-cutter bee; a, male; b, female; c, leaf-cutter at work; d, cell; e, parts of lining of cell.

metallic colors. The egg is white, oblong, and about the shape and size of a caraway seed. It hatches in about eight days, and the development of the larva is rapid. On reaching full growth it spins a delicate cocoon and winters as a pupa. Smith gives a remarkable case of retarded development with *Osmia parietina*. From a quantity of cells collected in Scotland in 1849, about one third only had given forth the adult bees. Some of the remainder issued the following year, while about thirty-five remained in the larva state until May, 1850, when they transformed and issued a month later.

The genus *Megachile* comprises the so-called "leaf-cutter" or "upholsterer bees." It is the most universally distributed genus of bees, and is found in all parts of the world. The female makes her cells of regular bits of leaf, which she cuts from a rose-bush or some similar plant. The pieces of leaf are either oblong or circular, the former being used for the sides, and the latter to cover the end of the cell. The burrows in which these cells are stored vary greatly in situation. Some species burrow into the ground, others into wood, while others make use of chance apertures.

Megachile centuncularis is one of our most common leaf-cutter bees. It is found through the northern United States and Canada, and all through Europe, as far north as Lapland. A single female of this species, observed by F. W. Putnam, occupied over twenty days in building and provisioning a series of cells under a board. On examination there were found to be thirty cells in nine rows of varying numbers. An estimation of the number of bits of leaf used in the construction of these thirty cells amounted to one thousand at the least. The curious Chalcid parasite, *Anthophorobia megachilis*, was bred in great numbers from this set of cells.

The bees of the genus *Anthidium* do not make burrows for themselves, but make use of those made by other insects. The large holes bored by the larvæ of *Cossus* are often used. The cells are made of down collected from woolly-stemmed plants, mixed with some glutinous matter. The little bees belonging to *Ceratina* excavate the pith of brambles. The common *Ceratina dypla* excavates stems of Syringa, elder, or blackberry, lining her cells with a delicate silky membrane and separating them from one another by mud partitions. This species is parasitized by a very remarkable chalcid of the genus *Azima*.

With the sub-family Scopulipedinae, the hind legs of the females are furnished with a thick coating of hairs which constitute the pollen-brushes. The basal joint of the posterior tarsi generally has its extremity angularly produced. They have no pollen-plates, and the abdomen is destitute of a pollen-brush. The wings usually have three perfect sub-marginal cells, the third antennal joint is often long and clavate, and the mouth is occasionally considerably developed.

The species of the genus *Eucera* burrow into the ground. The larvæ remain as such through the winter, transforming to pupæ in April without spinning cocoons. With *Anthophora* the habits are quite similar, but certain species bore into wood instead of entering the ground. The abnormal chalcid *Anthophorobia* (*Melittobia*) is parasitic upon bees of this genus according to Newport. There remains a doubt, however, as to whether or not it is a true *primary* parasite, as Smith discovered its larvæ feeding upon those of *Monodontomerus nitidus*, which is a true parasite of *Anthophora*. The correct conclusion seems to be that the larvæ of both *Monodontomerus* and *Anthophora* are destroyed by this parasite. The bees of the genus *Melicta* live in the burrows of *Anthophora* as previously stated. The genus *Saropoda* seems to connect *Anthophora* with the next genus, *Xylocopa*, as its species closely resemble the former in structure, while in habits they approach the latter. They are borers in decaying wood, making longitudinal burrows divided into eight or ten oval chambers, each containing a cell formed of wood scrapings.

The genus *Xylocopa* contains the largest species of the genus. They resemble, in general appearance, the common humble bees, but are less hairy. These bees bore symmetrical tunnels into solid wood, choosing, in civilized regions, fence posts and boards. The burrow is half an inch in diameter, and runs horizontally across the grain for about the length of the insect's body, when it is turned downwards at right angles and carried to a depth of from twelve to eighteen inches. In boring, the bee is said to progress at the average rate of about half an inch a day, occupying at least two days in digging the first portion against the grain of the wood. The tunnels generally run in opposite directions from the opening, and sometimes other galleries are made, one parallel with the other, using the common opening. It seems certain that the same tunnel is used over and over again, and that a new one is only made when no old one can be found. After the burrow is prepared, the cells are made and supplied with

pollen. The cells of *Ngilocopa virginica* are about seven tenths of an inch in length, and are separated from each other by partitions which are similarly constructed by the other species. Each partition seems to be made from a single flattened band of saw-dust and fine chips, agglutinated together and rolled up into a band about four layers deep. The side forming the bottom of the cell is concave and smooth, while the other side is flat and rough.

Last and highest in the order Hymenoptera comes the sub-family Socialinae, or social bees. The social bees are readily distinguishable from the other members of the family Apidae by several striking peculiarities. As with the social wasps, each species is composed of three classes of individuals, males, females, and drones, or workers. They live gregariously in larger or smaller communities. They have the power of secreting wax, from which their cells are made, and the larvae are fed from time to time by the workers. The outer side of the dilated posterior tibiae is smooth, and in the workers is hollowed into a shining plate for carrying pollen, which is collected by means of the pollen-brushes on the basal joint of the hind tarsi. The maxillary palpi are very small. As a general thing the body is covered with hair, though some Brazilian species of the genus *Euglossa* are naked.

The genus *Bombus* includes the so-called "humble" or "bumble" bees. In this genus the body is oblong and densely pubescent, mandibles stout, grooved exteriorly towards the rounded apex, labial palpi four-jointed, labium long, pubescent, maxillary palpi two-jointed, fore wings with one marginal and three sub-marginal cells. With the males the mandibles have a dense fringe of curled hair on their inferior margins. The genus has an extensive geographical range, and is found all over the world, with the exception of Australia and New Zealand. Into the latter countries it has been introduced, to aid in the fertilization of the clover crop. Over sixty species have been described from North America. The species are very difficult to separate, owing, principally, to the great colorational variation in the males. The economy of the genus has long been studied, and has been quite fully detailed by several authors. The females or queens alone hibernate. During the winter months they may be found, always singly, hidden away in decayed trunks of tree, under fodder stacks, under leaves, or moss, or in other sheltered and dry situations. That they sometimes winter in the old nests is both stated and disputed. In the spring each female becomes the foundress of a new colony. She selects some spot, under a stump or sod, or often in the abandoned nest of a field mouse, and immediately collects a mass of pollen which she mixes with honey, and in which she deposits a small number of eggs. The eggs, according to F. W. Putnam, are laid in contact with one another, in one cavity of the pollen mass, with which they are slightly covered. The larvae, hatching, begin feeding on the pollen, and push out in independent directions, increasing in size, and making large cavities in the mass. On reaching full size, each spins a silken covering, which is thickened by a wall of wax added by the adult bees, so that a cell is formed in which the larva transforms to a pupa. The development is very irregular, and a nest examined at almost any time during the summer will be found to contain the insects in almost all stages of growth. The first brood is composed of workers, and after their appearance the queen leaves the work of provisioning to them and devotes herself almost exclusively to home duties. The workers are assiduous in their labor of collecting and storing up pollen, and in their care of the young. They assist the newly-formed bees to emerge from their cocoons, helping them to cut and remove the lid, and pulling them out with their mandibles. More eggs are laid and new cells are

constructed, the peculiar manner in which the cells are made accounting for the irregularity in their arrangement. The nest rapidly increases in size, as the queen remains fertile throughout the summer. In the construction of their nests, the bees adapt themselves to circumstances in an interesting way, and avail themselves of such materials as are most readily found. Where moss is abundant, the nests are entirely constructed of this material, and Smith mentions an instance in which a female, founding a colony in the grass near a stable, collected a quantity of the bundles of horse-hair accumulated from the currying of horses, and composed her nest entirely of this substance. Another instance is mentioned where a female of *Bombus pratorum* took possession of the nest of a robin, built high up on a porch.

About the middle of the summer, eggs are deposited, from which hatch small females and males. The small females are supposed to be able to lay only male eggs. According to Putnam, all eggs laid by the queen after the last of July produce only the large females or queens, which, after impregnation by the males, seek suitable places for hibernation, while the other inhabitants of the nest die on the approach of cold weather.

The species of this genus are subject to the attacks of several parasites. Besides the species of the genus *Apathus*, which we shall consider next, many nests swarm with a species of *Acarus* which devours the wax and honey. The larvæ of *Tinea pellionella* abound in many nests. The two beetles *Anthrophagus glaber* and *A. ochraceus* feed upon the stored-up food, and *Anobium paniceum* is said to have the same habit. *Meloe* and *Stylops* also infest *Bombus*, and species of the dipterous genera, *Volucella*, *Conops*, *Anthrax*, and *Anthomyia* are also found in the nests.

The numbers of which the colonies of humble bees consist vary greatly with the different species. A nest of *Bombus fragrans*, examined by Smith at the end of August, contained only five females and twenty workers, while a nest of *B. terrestris*, examined at the same time, contained thirty-five females, twenty males, and one hundred and sixty workers, a total of two hundred and fifteen, and at this time a majority of the males and females were supposed to have left the nest.

The genus *Apathus* closely resembles *Bombus*. Nine North American species have been described. The economy of this genus is not well understood. Its species live in the nests of *Bombus*, the species of which they mimic in appearance, but what office they perform is not well known. A parasitic connection is conjectured, but not proven. They seem to be on the most friendly terms with their hosts. Smith says: "It has been supposed, from the very close resemblance of the *Apathi* to the *Bombi*, that the former are an idle race, reared at the expense of the industrious bees, and wearing a livery in imitation of them for the purpose of deception; but there can be little doubt of these aristocrats of the community performing important and necessary duties highly conducive to the general prosperity of the whole."

With the genus *Apis* the characters are as follows: *Males*.—Eyes very large, occupying one-fifth of the head, meeting on the vertex; posterior tibiae slender at base, gradually widening towards apex. *Females and Workers*.—Eyes lateral, elongate, not meeting on the vertex. Wings having one marginal and three sub-marginal cells; labial palpi four-jointed; maxillary palpi one-jointed. Eyes pubescent; posterior tibiae not spined; basal joint of posterior tarsi of workers concave, transversely ridged, each ridge having a thick-set fringe of stiff hairs. Male and female with simple tarsi.

The habits of the common honey bee (*Apis mellifica*) have been studied for many

years. On account of the value of its two main products, honey and wax, it has been domesticated by man, and the methods of bee-culture in use admit of ready study of its economy. Remarkable facts in its life history have been discovered, and are significant as indicating the possible results of an equally close study of the life history of other higher Hymenoptera. The life round has been briefly summed up as follows: "A fertilized queen, which, with a few workers, has wintered over, lays its eggs in the spring, first in the worker, and afterwards, at a later period, in the drone cells (both arranged in two perpendicular rows of cells). Early in the summer the workers construct the larger flask-shaped queen-cells, which are placed on the edge of the comb, and in these the queen larvae are fed with rich and choice nourishment. As soon as the first of the new brood of queens has been excluded from its cell, which it indicates by a peculiar buzzing noise, the old queen deserts the nest, carrying away with her a part of the swarm, and this forms a new colony. The recently excluded queen then takes its marriage flight high in the air with a drone, and on its return undertakes the management of the hive and the duty of laying eggs. When another queen is disclosed, the same process of forming a new colony goes on. When the supply of new

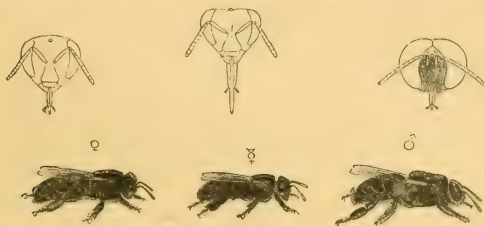


FIG. 665. — Queen, worker, and drone of *Apis mellifica*, honey bee.

queens is exhausted, the workers fall upon the drones and destroy them without mercy. The first brood of workers lives about six weeks in summer, and then gives way to a new brood. Mr. J. G. Desborough states that the maximum period of the life of a worker is eight months. The queens are known to live five years, and during their whole life lay more than a million eggs. (V. Berlisch). Langstroth states that 'during the height of the breeding season she will often, under favorable circumstances, lay from two thousand to three thousand eggs a day.' According to Von Siebold's discovery only the queens' and workers' eggs are fertilized by sperm cells stored in the receptaculum seminis, and these she can fertilize at will, retaining the power for four or five years, as the muscles guarding the duct leading from this sperm-bag are subject to her will. Drone eggs are laid by unfertilized queen bees, and in some cases even by worker-bees." When, from any cause, the supply of queen eggs runs short, a worker egg is transferred by the workers into a queen cell. There, either by the increased temperature of the cell, or by the larger quantity of food given the larva, or by the superior quality of this food, the egg produces a queen bee instead of the worker which would have come forth under ordinary circumstances.

The cells from which the drones or males are to be developed are slightly larger than the ordinary worker cells, as are also the cells devoted to the storing of honey.

The latter are formed either by enlarging the ordinary brood cells, or by constructing a new comb devoted entirely to the storing of honey. In opposition to the old theory as to the exact hexagonal character of the cell, Wyman has proved that the cells are all more or less imperfect.

The common honey-bee is now distributed all over the world. It was introduced into North America in the seventeenth century, and into South America in 1845. It was originally a native of Europe. The Italian and Syrian bees, although formerly considered distinct species, are now placed as varieties of *A. mellifica*.

The insect enemies of the hive bee are quite numerous. The larvæ of the two wax moths, *Galleria mellonella* and *Achroia alcearia*, consume the wax, breaking up the cells and spinning their webs, filled with excremental pellets, about in the hive. *Phora incrassata* is said to be a true parasite of bee larvæ in Europe, although there is doubt as to whether it may not act as a mere scavenger. The drones are infested by the two hair-worms, *Mermis albicans* and *Gordius sub-bifurcus*. A beetle known as *Trichodes apiarius* destroys the larvæ in Europe, and the bee-louse, *Braulta ceca*, infests the adult.

The indigenous honey-bees of the tropics belong to the genera *Trigona* and *Melipona*. The species are small and stingless, and form immense colonies. The honey of some species is excellent, while of others it is bitter in taste. Ordinarily they build in hollow trees, but certain species suspend their nests from branches, and one uses clay in its construction.

L. O. HOWARD.

EDITOR'S NOTE.—Mr. Howard is also the author of the accounts of the families Chalcidæ and Proctotrupidæ, included in the article of Professor Comstock.



FIG. 665. — Under surface of bee.

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